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Specification Guide for Snow Removal Vehicles for Rail Transit Systems

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161 Highland Avenue
Needham MA 02194

November 1983
Final Report

UMTA Technical Assistance Program

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16. Abstract

This Specification Guide for Snow Removal Vehicles for Rail Transit Systems is intended to be a guide for Snow Belt Rail Transit operators to use in the preparation of technical specifications for snow removal vehicles. It is not intended to be a procurement document. This Guide has been developed to provide the Purchaser with a choice as to the type of vehicle and options that will best satisfy site-specific needs.

Since the operating constraints of commuter rail are no more restrictive than those for Rapid Transit, Commuter Rail operators are encouraged to use this document in the development of their own technical specifications for snow removal vehicles.

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16. Abstract

During the Winter of 1977-1978, a major snow storm shut down the Boston transit system for almost a week and the Winter of 1978-1979 produced similar snow conditions that paralyzed the Chicago transit system and disabled more than half of their rail fleet. As a result of these disruptions and breakdowns, the Snow Belt transit operators became increasingly aware of the need for special measures that must be taken in order to maintain rail operation during severe winter conditions. This need was highlighted at the American Public Transit Association's conference in the Spring of 1979 at which time a Snow and Ice emergency Task Force was formed. This task force determined that a high capacity special purpose snow removal vehicle was needed by the industry, designed for removing the heaviest accumulation from a rail transit system's right-of-way. This Specification Guide is intended as a guide for Snow Belt rail transit operators to use in the preparation of technical specifications for the procurement of snow removal vehicles. It is not intended to be a procurement document. This Guide has been developed to provide the purchaser with a choice as to the type of vehicle and options that will best satisfy site-specific needs. Since the operating constraints of commuter rail are no more restrictive than those for rapid transit, commuter rail operators are encouraged to use this document in the development of their own technical specifications for snow removal vehicles. Only existing, proven design concepts are considered here in the interest of lower costs, shorter delivery times, and avoidance of costly prototype developments for each transit system. The three types of snow removal vehicles described in this Specification Guide are: 1) rail-mounted "jet" blower; 2) rail-mounted rotary blower; and 3) rail/highway rotary blower.

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PREFACE

During the Winter of 1977-78 a major snow storm in the Northeast shut down the Boston transit system for almost a week and the Winter of 1978-79 produced similar snow conditions in the Midwest that paralyzed the Chicago transit system and disabled more than half of their rail fleet.

As a result of these disruptions and breakdowns, the Snow Belt transit operators became increasingly aware of the need for special measures that must be taken in order to maintain rail operation during severe winter weather conditions. This need was highlighted at the American Public Transit Association's Rail Transit (APTA) Conference in the Spring of 1979 at which time a Snow and Ice Emergency Task Force was formed. This task force determined that a high capacity special purpose snow removal vehicle was needed by the industry, designed for removing the heaviest accumulation from a rail transit system's right of way.

This Specification Guide was prepared by Alexander Kusko, Inc., Needham Heights, MA., under contract to the U.S. Dept. of Transportation, Research and Special Programs Administration, Transportation Systems Center, Cambridge, MA., under the auspices of the U.S. Dept. of Transportation, Urban Mass Transportation Administration, Office of Systems Engineering Design Division.

Mr. Jason Baker of the Office of Systems Assessment, Maintenance and Productivity Division, at the Transportation Systems Center played a vital role and provided valuable suggestions, throughout the many reviews of this guide, as project manager for this project.

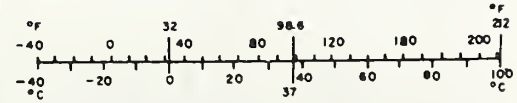
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimetsrs	cm
yd	yards	0.9	metsrs	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	squsre centimeters	cm^2
ft^2	square feet	0.09	squars meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	squsre kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teespoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (sfter subtracting 32)	Celsius temperature	°C

Approximate Conversians from Matric Measures

Symbol	When Yeo Keow	Multiply by	To Fiod	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	milss	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	squars miss	mi^2
ha	hectares (10,000 m^2)	2.5	scres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

1.1 Purpose

This document was prepared to assist rail transit agencies in the preparation of specifications for the procurement of snow removal vehicles for their rail systems. Only existing, proven design concepts are considered here in the interest of lower costs, shorter delivery times, and avoidance of costly prototype developments for each transit system. Those commuter rail systems that have similar snow removal requirements should also find this document a useful aid.

Three logical steps must be taken to generate a specification for procurement of a new snow removal vehicle:

1. Assessment of the site-specific snow removal needs.
2. Selection of the most suitable vehicle type.
3. Generation of a procurement specification that incorporates the design features needed to obtain the required performance in service, using available hardware.

This document was prepared to assist a rail transit agency (hereafter called a "Purchaser") in performing each of these three steps.

The site-specific factors that determine snow removal needs include the expected snowfall, the presence of deep cuts, the ruling grades, the sharpest curves, location of third rail (if used) relative to running rails, clearance profiles for station platforms, bridges, and tunnels, and access to shop facilities.

Selection of the most suitable type of snow removal vehicle is made by comparison of the performance capabilities of the three generic vehicle types, as described here. Such factors as the snow removal rate, ability to clear snow down to the top of the rails, in conformance with the Purchaser's clearance template, ability to clear the third rail of snow and ice, ability to tow stalled vehicles, and ability to clear rail yards as well as the right-of-way are considered for each vehicle type. The effect of weather and snow on the performance of each vehicle type shall also be considered.

Generation of an effective vehicle procurement specification requires that all the necessary performance needs and design features be included in the specification while those performance needs and design features that are not needed should not be included. This document provides an extensive listing of the possible performance needs and the available design features for each of the vehicle types, as an aid in preparation of a site-specific specification.

1.2 Potential Purchasers

Those transit authorities (and commuter rail systems) that are potential purchasers of snow removal vehicles are listed below:

Baltimore Regional Rapid Transit System	(BRRTS)
Chicago Transit Authority	(CTA)
Greater Cleveland Regional Transit Auth.	(GCRTA)
Long Island Rail Road	(LIRR)
Massachusetts Bay Transportation Authority	(MBTA)
New York City Transit Authority	(NYCTA)
Niagara Frontier Transportation Authority	(NFTA)

Port Authority of Allegheny County	(PAT)
Port Authority Trans-Hudson Corporation	(PATH)
Port Authority Transit Corporation	(PATCO)
Southeastern Pennsylvania Transportation Authority	(SEPTA)
New Jersey Transit	(NJT)
Tri-County Metropolitan Transportation District of Oregon	(TRI-MET)
Washington Metropolitan Area Transit Authority	(WMATA)

1.3 Vehicle Description

The three types of snow removal vehicles described in this Specification Guide are (1) rail-mounted "jet" blower, (2) rail-mounted rotary blower, and (3) rail/highway rotary blower.

The rail-mounted "jet" blower utilizes a gimbal-mounted aircraft-type jet engine with its exhaust jet directed both forward and down towards the rail. Cab controls direct the blower to either side and up or down, within the gimbal limits. The vehicle features a center lifting device which lifts the vehicle clear of the rail and allows it to be turned to reverse the direction of forward travel.

The rail-mounted rotary snow blower vehicle is a heavy duty vehicle that can handle the deepest snow drifts and can perform well with snow of any consistency. This vehicle features two two-axle trucks, a rail-mounted diesel-powered two-stage rotary snow blower, and either direct drive, hydrostatic drive or electric drive, for both propulsion and snow removal. This vehicle can feature a rotary blower and a cab on one end or on both ends, at the discretion of the Purchaser.

The rail/highway rotary blower vehicle with its "hi-rail" wheel assemblies has the capability of traveling and removing snow on both highway and rail. It also has a wide selection of attachments that make it a versatile work vehicle. A center lifting device installed on the undercarriage permits a reversal of the direction of forward travel, when rail-mounted, and also permits the vehicle to become rail-mounted at any point in the rail network.

Performance requirements and design features for each of the three types of snow removal vehicles are described in Sections 7, 8 and 9. Design alternatives and available optional snow removal equipment for each vehicle type are also described in these sections.

2.0 STANDARDS AND DEFINITIONS

2.1 Government and Industry Standards

Materials and construction practices used to manufacture the vehicle shall conform to applicable government and industry standards. Standards in such areas as exhaust emissions, smoke emissions, flammability, noise, fuel, hydraulics, pneumatics, and electrics shall also apply. Applicable codes and standards are mentioned in the appropriate sections of this document.

A listing of applicable government and industry organizations that generate these standards and codes (and their abbreviations) follows:

AAR	Association of American Railroads
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge
AWS	American Welding Society
DOD	United States Department of Defense
DOT	United States Department of Transportation
FAA	Federal Aviation Administration
IEEE	Institute of Electrical and Electronics Engineers
II	Industrial Institute
IPCEA	Insulated Power Cable Engineers Association
ISO	International Standards Organization
NFPA	National Fire Protection Association
NFPA	National Fluid Power Association

OSHA	Office of Safety and Health Administration
SAE	Society of Automotive Engineers
UL	Underwriters' Laboratories, Inc.
UMTA	Urban Mass Transportation Administration

2.2 Glossary of Terms

Items listed in the glossary below are defined as they are used in this document.

Auger - A screw-shaped or helical cutter used to break up and move snow as the vehicle advances. Also called a rotary cutter. The first stage of a 2-stage rotary snow blower and the only stage of a one-stage rotary snow blower.

Azimuth - A bearing angle. The direction at which snow is discharged.

Bearing life, B-10 - The total miles of bearing service life at which the probability of a failure due to wearout or fatigue is 10 percent.

Brake actuator - A device that, when applied, forces the brake shoes against the wheel treads or the brake pads against the brake discs to retard the motion of a vehicle. A direct-acting brake actuator uses pneumatic pressure to apply the brakes, while a fail-safe brake actuator uses pneumatic pressure to release the brakes, which are otherwise applied by a spring force.

Cardan shaft - A mechanical drive shaft used to transmit power from the prime mover to a driving axle, or from one truck axle to the second truck axle.

Center lifting device - A device used to reverse the direction of forward travel of a single rail vehicle. Mounted below the vehicle mass center, this powered device can elevate a parked vehicle so that it can be manually rotated a half turn then lowered onto the rails. Usually hydraulically powered, but an electric motor drive is also possible.

Clearance profile diagram - An engineering drawing showing the locations of the third rail, station platforms, and other wayside equipment in relation to the running rails. Used to define vehicle clearance criteria.

Clearance template - A graphical description of the cross section to be swept out by the advancing snow blower. This template or snow removal profile is specified by the Purchaser.

Control interlock - In general, a means of ensuring that some equipment or operating mode is not employed or allowed to operate unless certain conditions are met.

Control valve - A hydraulic valve used to operate either a hydraulic drive or a hydraulic-powered device.

Coupler support - A moveable U-shaped member that holds a coupling head for mating with another vehicle. When the support is lowered to a horizontal position, coupling can occur. The support is rotated to a vertical position when not in use.

Dead-man emergency release valve - A fail-safe hydraulic foot valve that must be continually actuated by the operator for the emergency release of locked-up brakes by use of a hydraulic hand pump.

Dead-man throttle valve - A fail-safe throttle control valve that must be continually actuated by the operator in normal use to avoid an irrevocable emergency application of the brakes. May be either a hand valve or a foot valve.

Discharge chute - The metal tube that directs the stream of discharged snow.

Discharge nozzle - A sheet metal enclosure used to direct "jet" blower exhaust gases towards the rails.

Diverter valve - A hydraulic valve used to change the hydraulic or hydrostatic drive motor connections from a parallel configuration to a series configuration as the vehicle gains speed.

Double-ended vehicle - A vehicle with identical cabs and rotary snow blowers on each end.

Dynamic outline - The vehicle frontal profile outline, extended by dynamic motion due to spring deflections and track irregulatiries. This dynamic outline must lie entirely within the clearance profile diagram.

Electric drive - An alternative to hydrostatic drive. A diesel-driven alternator or dc generator provides power to the traction motors that drive the axles on each truck.

Emergency braking rate - A maximum braking effort that applies a deceleration rate of 3.0 mi/hr/sec.

Emergency hand pump - A manually operated hydraulic pump located inside the cab and used to provide hydraulic pressure for emergency backup operation of hydraulic devices, such as coupler support and center lifting device, as well as for emergency release of locked-up pneumatic fail-safe brakes.

Emergency stop valve - A means for rapidly releasing pneumatic pressure to the brakes to provide an abrupt emergency stop. Also operable as a parking brake if applied when the vehicle is not in motion.

Engineer's valve - A hand-operated rotary valve used to apply and release the pneumatic brakes.

Fail-safe pneumatic brake - A pneumatic braking system where the braking force is applied by springs and is released by the application of pneumatic pressure.

Front-end broom - A large rotary broom that can be mounted to the front end of a vehicle for clearing snow. Usually hydraulically driven.

Front-end plow - A steel plow that can be mounted on the front end of a vehicle for clearing snow. Can be either V-shaped or a straight blade.

Gimballed mount - A two-axis mount used to support the "jet" engine (with attached discharge nozzle) on a "jet" blower vehicle. Each axis is cab controlled and hydraulically actuated to direct the hot "jet" exhaust gases as desired.

Helical cutter - The auger of a rotary snow blower.

Human factors - The many characteristics, capabilities, and limitations of the human operators and crew that must be considered when designing a manned vehicle.

Hydraulic system - A pressurized fluid system consisting of pumps, motors, reservoir, control valves, and suitable piping and valves used for providing a remote power-assist for various tasks, such as positioning of snow discharge chutes, operating a center lifting device, etc.

Hydraulic actuator - A hydraulic-powered piston or ram. Used as a positioning device.

Hydraulic pump - A mechanically driven pump used to pressurize the hydraulic system.

Hydraulic reservoir tank - A steel pressure vessel used to hold pressurized hydraulic fluid.

Hydraulic coupling - Generally, a fitting at the end of a hydraulic line used to connect to another hydraulic line. Also, a hydraulic fitting installed on a vehicle and used to attach to removable hydraulically powered optional equipment.

Hydrostatic drive - A pressurized fluid system consisting of pumps, motors, reservoir, control valves, and suitable piping and valves used to provide a critical portion of the power train from the diesel engine power source to the vehicle drive wheels. Hydrostatic drives are generally operated at pressures above 4000 lb/in^2. Control of vehicle speed is obtained by adjusting the flow rate of the hydraulic field. A hydrostatic drive can also be used to power a rotary snow blower.

Hydrostatic motor - Similar to a hydraulic motor, but designed to operate in a higher pressure range (above 4000 lb/in^2).

Hydrostatic pump - Similar to a hydraulic pump, but designed to operate in a higher pressure range (above 4000 lb/in^2).

Hydrostatic reservoir tank - A steel pressure vessel used to hold pressurized hydrostatic fluid.

Impeller - A high-speed vaned rotor such as the second stage of a 2-stage rotary snow blower. The impeller takes snow from the first stage (auger), accelerates it, and discharges it through the primary chute.

Interlock - Same as control interlock.

"Jet" blower - A snow blower that generates hot exhaust gases from an aircraft-type jet engine to both blow and melt snow, clearing the rail right-of-way and special trackwork.

"Lap" - A position on the Engineer's valve that will maintain a constant braking rate equal to the Service braking rate in effect at the moment the valve is placed into the "Lap" position.

Mechanical drive - A design alternative to the hydrostatic drive. A wide-range gearbox and a manual clutch or a hydraulic-actuated transmission, as well as gearing, cardan shafts, etc., transfers diesel engine power to the drive wheels.

Number 1 fuel - A lighter commercial grade of distillate oil suitable for use in a diesel engine. Properties of No. 1 oil are defined in ASTM D396-48T.

Number 2 fuel - A heavier commercial grade of distillate oil suitable for use in a diesel engine. Properties of No. 2 oil are defined in ASTM D396-48T.

Pneumatic brakes - Vehicle brakes that either use pressurized air to either apply the brakes (direct-acting) or to release the brakes (fail-safe). Highway vehicles use direct-acting brakes and rail vehicles generally use fail-safe brakes.

Power take-off - A pulley drive wheel provided on the chassis of a vehicle to provide belt-driven power to optional equipment, when used. Driven by the diesel engine, the power take-off is cab controlled.

Primary chute - A snow discharge duct on a rotary snow blower which takes snow from the impeller and either discharges it directly for a maximum range at a fixed azimuth, or discharges it into the spotcast chute for a reduced range and a controlled azimuth angle.

Primary suspension - The four rubber-tired wheels with associated springs and shock absorbers that are used for all highway and rail modes of operation of a rail/highway vehicle. In the highway modes, the primary suspension supports the entire vehicle weight; in the rail modes, the primary suspension supports the major portion of the vehicle weight.

Rotary cutter - The auger of a rotary snow blower.

Rotary head - The rotary mechanism of a rotary snow blower (see below).

Rotary mechanism - The helical cutter or auger (first stage) of a rotary snow blower, and the impeller (second stage), if used. Also called rotary head.

Rotary snow blower - A powered device coupled to the leading end of a vehicle for snow removal. Consists of a frame, rotary mechanism, discharge chute(s), and hydraulic actuators for control.

Roof-mounted ice scraper - An optional device used to remove ice from the overhead catenary contact wire (if used) and supported on the upper end of the pantograph or trolley pole.

Ruling grade - The steepest grade on the Purchaser's rail network.

Sander - A device used to deposit sand on the rails ahead of the leading wheels for improving traction.

Secondary suspension - Retractable steel flanged guidewheel assemblies mounted on a rail/highway vehicle. Used for the rail modes of operation.

Service braking rate - A braking rate ranging from a minimum value up to the maximum service braking value of 2.5 mi/hr/sec. The Engineer's valve is set to "Service" to apply an increasing value of braking rate until the desired value is obtained.

Shear pin - A load-carrying member in the rotary snow blower drive that is designed to break by shearing to prevent damage to the auger and/or impeller positions of the rotary mechanisms, should foreign objects lodge in the mechanism and cause it to be jammed.

Single-ended vehicle - A vehicle with one cab and a rotary snow blower located on the front end.

Snow brake - A feature of a braking system to improve braking performance under inclement winter weather conditions. The snow brake applies a small, constant braking force to keep each brake shoe against its wheel tread, preventing snow and ice buildup between the brake shoe and wheel tread.

Snow removal rate - The rate at which snow is cleared from the right-of-way. Measured in tons/hour.

Spotcast chute - A form of discharge chute used on both single-stage and 2-stage rotary snow blowers. The spotcast chute accepts snow from the primary chute and controls the discharge range and direction.

Truck-mounted brushes - Non-conductive, rotating, power-driven brushes mounted on a vehicle forward truck to sweep the third rail clear of snow.

Truck-mounted deicer head - A flat hollow head with a series of holes on its lower face that is mounted on a vehicle truck and used to dispense a deicing solution onto the third rail.

Truck-mounted ice scraper - An assembly with steel blades mounted on a vehicle truck that, when actuated, forces the steel blades onto the contact surface of a third rail to clear the rail of ice when the vehicle is in motion. This scraper is electrically insulated from the vehicle truck and body.

Turnable vehicle - A rail-mounted vehicle that, by means of a center lifting device, can be rotated so that the front end travels forward in the opposite direction.

Vee plow - A v-shaped or wedge-shaped snow plow that can be mounted on the front end of a vehicle.

3.0 OPERATING ENVIRONMENT

The operating environment for a snow removal vehicle is determined by the weather conditions that it will be exposed to as well as the pertinent features of the site-specific environment where it will be placed in service. The significant features of the operating environment are discussed below.

3.1 Weather

The vehicle shall be capable of removing snow under all extremes of winter weather encountered at the Purchaser's site. If the vehicle is also used in the summer to perform other duties, then it must also be capable of operation under all extremes of summer weather encountered at the Purchaser's site.

Winter weather shall include any combination of the following conditions:

- Temperatures as low as -40°F (-40°C).
- Wind velocity as high as 100 mi/hr.
- Precipitation in the form of snow, ice, freezing rain or sleet up to 4 in/hr.
- Snow accumulations up to 2 ft above the rails, with drifts up to 3 ft. Snow density can range from 5 lb/ ft^3 (driest powder) to 45 lb/ft^3 (wet, packed snow).

3.2 Site-Specific Features

The vehicle shall be capable of removing snow on the Purchaser's rail network taking into consideration site-specific constraints such as:

- Clearances (third rail, tunnels, bridges, platforms, wayside equipment, etc.).
- Curves
- Grades
- Location of third rail
- Condition of track
- Posted speeds
- Elevation above sea level.

The vehicle under car equipment shall clear the tops of the running rails by at least 2.5 inches, with fully worn wheels.

The Purchaser shall supply a clearance profile diagram to the Contractor, which shall show locations of station platforms, third rails and other pertinent clearance restraints.

The vehicle shall be capable of operating on the shortest radius curves on the Purchaser's rail network (minimum radius of ____ ft). *

The vehicle shall be capable of operating on the steepest grades on the Purchaser's rail network (ruling grade of ____ percent).

*It shall be noted that wherever a blank space (underlined) is in the text, the information required shall be furnished by the Purchaser.

4.0 MATERIALS AND WORKMANSHIP

4.1 General

All materials chosen for use in the fabrication of the snow removal vehicle shall be such that they will economically and safely perform satisfactorily under their operating environment and in accordance with their intended function. All components and assemblies shall be free from sharp edges, hazardous protrusions, cracks or other elements which might cause injury to personnel or equipment.

Material composition, properties and performance shall conform to the applicable standards. Whenever a commercial material is not covered by a specification, the material shall be identified by the commercial trademark, and name and address of the Supplier. A description of the material composition shall also be available, and substitute materials shall be used only with approval of the Purchaser.

4.2 Metals

4.2.1 Steel

All materials and workmanship shall conform to the requirements of the indicated standard for the designated steel.

Material	Applicable Standard	Notes
1. Steel Castings		
General Purpose Castings	ASTM A27, Grade 65-35 or Grade 70-36	general application except traction motor
High Strength Steel Castings	ASTM A148, Grade 80-40 or Grade 90-60	for application in members subjected to higher mechanical stresses than above, e.g., traction motor
Low Alloy Nickel	AAR M-201	for truck frames

	Material	Applicable Standard	Notes
2.	Heat-Treated Alloy Steel	ASTM A514, Grade F	suitable for welding and other structural purposes
3.	Low Alloy, High Tensile Steel	ASTM A242	nickel alloy, corrosion-resistant steel; high tensile strength
4.	Steel Forgings		
	Carbon Steel Forgings	ASTM A236, Grade F	double-normalized and tempered; for heavy-duty service
	Alloy Steel Forgings	ASTM A238, Grade F	normalized, quenched and tempered; for special heavy-duty service
5.	Steel Bolts		
	Carbon Steel Bolts or High Strength Structural Bolts	ASTM A325	for structural joints
	Alloy Steel Bolts	ASTM A354, Grade BD or ASTM A490	for high-strength structural steel joints

4.2.2 Fasteners

All mechanical fasteners shall conform to ANSI standards, unless otherwise indicated or approved. All fasteners shall be stainless steel, or chromium plated steel or galvanized or cadmium plated steel, or zinc plated steel per ASTM B633. Cadmium plating shall conform to ASTM A165, Type NS. Chromium plating shall be according to

ASTM A166, Type DC. Galvanizing shall be hot-dip with a minimum thickness of 0.025 mm (0.001 in) purest quality zinc. Fasteners shall be of the threaded type and shall conform to ANSI Class 2 requirements, unless otherwise indicated. All fasteners shall either be self-locking or provided with locking devices of lockwire, lockwashers or locknuts, as appropriate. Lockwire (if used) shall be stainless steel. Lockwires of diameter smaller than 2 mm (0.075 in) shall conform to commercial standards; diameters of 2 mm (0.075 in) and greater shall conform to Military Std. Part MS35340. Locknuts shall be of the nylon collar insert type or deformed type. The bolt shall have chamfered ends and at least 1-1/2 threads shall project through the nylon locking collar or outer interference thread. Bolts for use with locknuts shall not be heated or drilled for cotter pins. All locknuts shall comply with the Industrial Institute requirements with regard to locking ability.

Steel bolts shall conform to the requirements of ASTM A325 or A490, as applicable. Nuts shall meet the requirements of ASTM A194, A325 or A563, as applicable. All steel screws, bolts, and nuts shall be cadmium plated, or zinc plated with a chromate treatment, except for stainless-to-stainless joints where stainless steel bolts and nuts shall be used.

4.3 Non-Metals

All combustible materials used in vehicle fabrication shall satisfy the flammability, smoke emission and toxicity requirements cited in Section 4.3.4. In addition, the following requirements shall apply for all non-metals.

4.3.1 Elastomers

Elastomeric parts may include door and window seals, glazing strips, truck bumpers and snubbers, structural and compressible gaskets, and mounting pads. All such parts shall be composed of neoprene or other suitable elastomers compounded and cured to perform satisfactorily under the environmental conditions in which the vehicle may be operated.

Elastomeric materials shall have the following minimum properties when tested in accordance with the applicable specification.

Physical Property	Test Method	Performance Requirement Value
Hardness, durometer A	ASTM D2240	45 to 75
Ultimate Elongation	ASTM D412	300%, minimum
Tensile Strength	ASTM D412	10.3×10^6 Pa (1,500 psi) minimum
Tear Resistance	ASTM D624	35,000 N/m (200 lb/in) minimum
Brittleness Temperature	ASTM D746	-40° C(-40° F)
Resistance to oil aging	ASTM D471	+80% change in volume, maximum
Resistance to heat aging:	ASTM D573	
- Max. change in elongation		-40%
- Max. change in tensile strength		-15%
- Max. change in hardness, durometer A		-5 to +15
Ozone resistance	ASTM D1149	No cracks
Resistance to permanent set	ASTM D395 (Method B)	25% compression set, maximum

4.3.2 Resilient Foam

All foam materials shall be graded and labeled in accordance with the requirements indicated and in standard with the recognized industry

associations or underwriters. Molded material shall have a high resistance to flexing, tearing, wetting and exposure to flame. Dimensions of neoprene foam rubber products shall conform to the requirements of ASTM D1055.

4.3.3 Glass

Laminated clear safety sheet glass of 3/16 in. thickness shall be used exclusively with the exception of windshields. Laminated clear safety plate glass of 1/4 in. thickness shall be used for all windshields. All safety sheet glass and safety plate glass shall be made up of two layers of glass laminated to a center sheet of plasticized polyvinyl-butyral resin of not less than 1.1 mm (0.045 in) thickness. There shall be no remarkable variations in color in the individual sheets of laminated plate or sheet glass when examined over a white background.

Edges of all glass shall be smooth cut after fabrication. Any overlap of one sheet of glass with respect to the other at an edge shall not exceed 0.8 mm (1/32 in). The overall dimensions of individual sheets as supplied shall be held within 1.6 mm (1/16 in) of the dimensions ordered, and its thickness tolerance shall not exceed 0.8 mm (1/32).

Laminated glass materials used in manufacturing windshields, cab side windows and cab rear windows, including cab door window shall be designed to meet the requirements of the following sections of ANSI Z26.1:

Test as per ANSI Z26.1	Windshields	All other Cab Windows
Light Stability	X	X
Luminous Transmittance	X	X
Humidity Test	X	X
Boil Test	X	X
Impact, Dart, 30 ft (9.14 m)	X	X
Impact, Ball, 30 ft (9.14 m)	X	X
Abrasion Resistance	X	X
Deviation and Distortion	X	
Penetration Resistance	X	

Impact tests shall be in accordance with those prescribed for "passenger cars" in Federal Register, Vol. 44, No. 251, Part 223, Appendix A.

4.3.4 Flammability and Smoke Emission Requirements

All combustible materials used in vehicle fabrication shall satisfy the flammability and smoke emission requirements cited in this section.

4.3.4.1 Material Requirements

When tested in accordance with the various specifications shown hereunder, the materials shall exhibit the indicated properties.

Notes:
Transit agencies should require certification that combustible materials to be used in the construction of vehicles have been tested by a recognized independent testing laboratory, and that the results are within the recommended limits.

Although there are no Recommended Fire Safety Practices for electrical insulation materials, information pertinent to the selection and specification of electrical insulation for use in transit fire environments is contained in the following UMTA reports:

Cateogory	Material Application	Fire Test[3]	Maximum Test Limits
Seating	Cushion[1; 2; 5]	ASTM D-3675	$I_s \leq 25$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Frame[1; 5]	ASTM E-162	$I_s \leq 35$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$[4]
	Upholstery[1; 2; 3; 5]	FAA 25.853	Flame Time $\leq$ 10 sec; burn length $\leq$ 6 inch
		NFPA 258	$D_s(4.0) \leq 250$ coated $D_s(4.0) \leq 100$ uncoated;
Panel	Wall[1; 5]	ASTM E-162	$I_s \leq 35$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Ceiling[1; 5]	ASTM E-162	$I_s \leq 35$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Windscreen[1; 5]	ASTM E-162	$I_s \leq 35$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Window[1; 4; 5]	ASTM E-162	$I_s \leq 100$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$

Notes: (cont'd)

- Electrical Insulation Fire Characteristics, Volume I, Flammability Tests, December 1978. (UMTA-MA-06-0025-79-1)
- Electrical Insulation Fire Characteristics, Volume II, Toxicity, December 1978. (UMTA-MA-06-0025-79-2)
- Combustibility of Electrical Wire and Cable for Rail Rapid Transit Systems, Volume 1, Flammability May 1983. (UMTA-MA-06-0025-83-6; Volume II, Toxicity May 1983 UMTA-MA-06-0025-83-7)

Category	Material Application	Fire Test[3]	Maximum Test Limits
Insulation	Thermal[1; 2; 5]	ASTM E-162	$I_s \leq 25$
		NFPA 258	$D_s(4.0) \leq 100$
	Acoustic[1; 2; 5]	ASTM E-162	$I_s \leq 25$
		NFPA 258	$D_s(4.0) \leq 100$
	Elastomers[1]	ASTM C-542	Pass
Miscel-laneous	Exterior Shell[1;5]	ASTM E-162	$I_s \leq 35$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$
	Component Box Covers 1; 5	ASTM E-162	$I_s \leq 35$
		NFPA 258	$D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$

Notes:

1. Materials tested for surface flammability shall not exhibit any flaming dripping or flaming running.
2. Flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, according to FED-STD-191A Textile Test Method 5830.
3. Flammability and smoke emission characteristics should be demonstrated to be permanent by dry-cleaning, if appropriate, according to AATCC-86. Materials that cannot be washed or dry cleaned should so be labeled and should meet the applicable performance criteria after being cleaned as recommended by the manufacturer.
4. For double window glazing, the interior glazing should meet the materials requirements specified herein, the exterior glazing need not meet those requirements.
5. NFPA-258 maximum test limits for smoke emission (specific optical density) should be measured in either the flaming or non-flaming mode, depending on which mode generates the most smoke.

4.3.4.2 Fire Test Provisions

The above fire tests shall be made in accordance with the following provisions.

For all materials, except elastomers, maximum test limits shown in the table for smoke generation in accordance with NFPA 258 apply in either flaming or non-flaming modes, whichever is greater.

For upholstery, materials of the same lot shall be tested for vertical flame resistance, in accordance with FAA 25.853, with a minimum of five specimens from each of the warp and fill directions and their results averaged (arithmetic mean).

Thermal and acoustic insulation materials shall be tested for surface flammability, as specified in the table, using wire mesh screening (as per section 5.92 of ASTM E-162).

4.3.4.3 Electrical Insulation

Selection criteria and specifications for electrical insulation are contained in the following report:

UMTA-MA-06-0025-79-1, "Flammability Tests," December, 1978.

Specifically, the following tests shall be used:

1. Vertical Flammability Test for Wire Sizes 20 AWG - 4 AWG, Section 4.1.5.1, with Pass/ Fail Criterion Section 4.1.6.1;

2. Vertical Flammability Test for Wire Sizes Larger than 4 AWG, Section 4.1.5.2, with Pass/ Fail Criterion Section 4.1.6.1;

3. Horizontal Flammability Test, Section 4.1.5.3 with Pass/ Fail Criterion Section 4.1.6.2;

4. Smoke Emission Test, Section 4.2.5 with Pass/Fail Criterion that heavy insulations which smoke as heavy or worse than PVC and chlorinated sulfonated polyethylene shall not be used.

As a guideline for further consideration of the selection of electrical wire insulation, the following reports shall be used: UMTA-MA-06-0025-79-2; "Toxicity", December, 1978, UMTA-MA-06-0025-83-6 Flammability, May 1983 and UMTA-MA-06-0025-83-7 Toxicity, May 1983.

4.3.5 Plywood

Treated plywood shall be certified to meet the flame resistance requirements of MIL-19140-C and shall not exceed the fire hazard classifications according to ASTM Test Method E119 latest revision. Treated plywood shall be primed or sealed as soon as possible after fabrication and shall be stored under cover. Metal-faced plywood core panels (plymetal) shall conform to the requirements of MIL-P-8053C. Honeycomb core panels shall satisfy the requirements of MIL-C-7438D, MIL-H-21040A and MIL-A-9067C.

4.4 Welding

All welding, unless otherwise specified shall be in accordance with the requirements of the applicable American Welding Society (AWS) specifications or other approved specifications. All welders shall have been tested to determine their ability to operate the welding equipment to be used making the required welds and to produce

satisfactory welds. The Purchaser shall have the right to require the making of test welds by any operator to ascertain his competence and to determine the suitability of the welding procedure used.

4.4.1 Welding Materials

The choice of welding rod or wire filler metal shall be made with adequate consideration of the make, type, size, composition, and suitability to the application, and shall be in accordance with Chapter 94 of the AWS Welding Handbook. Welding electrodes for steel, for manual shielded metal-arc welding, shall conform to applicable AWS standards or the E60 or E70 series. Bare electrodes and granular flux used in the submerged-arc or gas metal arc process shall conform to the provisions of AISC Section 1.17.3. The welding materials for stainless steel (if used) shall conform to the provisions and recommendations of Section IX of the ASME Boiler and Pressure Vessel Code.

4.4.2 Welding Procedures

Proper welding procedures shall be followed for all welding performed by the Contractor. Before welding of any sort is started, parts to be joined shall be properly cleaned. Corrosion, rust, oil, water and other foreign material shall be removed by an approved process or method. All parts to be joined by welding shall be adequately supported throughout the welding operation to ensure minimal distortion. The method used in depositing weld metal shall be chosen such that warping and residual internal stresses shall be minimized. To achieve this, tack welding, offset welding, skip welding and other devices and sequences well known in the art shall be used, where appropriate. A stress relieving process

suitable for the type of material shall be employed to remove residual stresses. The weld metal shall be made to penetrate into the bottoms of angles and vees and complete fusion at these points shall be ensured.

Fillet welds shall be extended around the ends of members wherever practicable. Manual welds which have a thickness greater than 1/4" shall be made with at least two beads. Machine welds of any thickness may be made with one or more beads as approved by the Purchaser. In any welding operation, the scale shall be completely cleaned off the underlying bead and surrounding metal before the next bead is applied. All grinding of welds shall be performed in the direction of the weld. All welding shall be such that complete and adequate fusion with the base material is achieved throughout the weld.

Resistance welding operations shall be undertaken only with equipment fitted with time, current, and pressure control. Accurate control of cleanliness, time, current, electrode size and shape, and pressure required to produce welds of specified strength shall be maintained. The Contractor shall determine experimentally or otherwise, the proper settings of the controls and shall provide against unauthorized changes. Similarly, the shape, size, and surface conditions of electrodes required to give satisfactory welding and acceptable finish shall be determined and recorded. Sample welds shall be subject to Purchaser's approval and shall be made and tested by either the shear-strength or the tear-test method. Complete records of the test results shall be maintained by the Contractor. All surface marks resulting from welding shall be treated in order to eliminate any visible defects in the finished surface.

4.5 Paint and Painting

All interior and exterior surfaces of the vehicle body, as required, shall be painted in accordance with Purchaser's instructions as to color scheme, stripping, and lettering, using products supplied or recommended by a paint manufacturer approved by the Purchaser. The surfaces to be painted shall be free of rust, scale, grease, and other foreign material just before the application of the primer or finish coat. All body dents, roughness, or other surface imperfections shall be made good prior to application of the first priming coat.

All paint shall be mixed, thinned, or otherwise prepared for application in accordance with the paint manufacturer's recommendations. Thinning materials or paint additives shall be only those recommended or approved by the paint manufacturer.

Painting materials shall be either brushed or sprayed as recommended by the paint manufacturer. There shall be uniform application of each coat over all surfaces to be painted, such that a neat appearance free from runs, sags, "orange peel", or other application defects shall be achieved. Top coatings must not contain lead, mercury or copper. All painted surfaces which become scratched or damaged during shipment, storage, handling or installation shall receive touch-up paint as required to present a satisfactory appearance. Touch-up paint shall be identical in all respects to original paint.

4.6 Bearings and Lubrication

All rotary shafts shall be supported by cylindrical or tapered roller bearings where practicable. As an option, ball bearings may be used, subject to the Purchaser's approval. All bearings vulnerable to airborne and liquid contamination shall be sealed. Standard grease fittings or plugs shall be provided for all bearings not internally splash or bath lubricated. Subject to Purchaser's approval, ball-bearings of one-inch shaft size and smaller may be factory "lubricated for life". Bearings shall be installed and removed without major disassembly of related components, and in no case shall thrust be carried across the rolling elements in pressing a bearing into its seat. Bearings and lubricants shall perform satisfactorily within their operating environment.

If space limitations preclude the use of anti-friction bearings, sleeve bearings shall be used to support rotary shafts. Sleeve bearings and bushings shall be assured full fluid film lubrication by oil bath, wick, drip oiler, or other Purchaser-approved methods. Self-lubricated bearings (sintered metal) shall not be used for shafts with speeds greater than 500 rpm. Sleeve bearings supporting ferrous shafts shall be composed of bronze, brass or aluminum alloys, as approved by the Purchaser.

All lubricants shall be products approved by the manufacturer of the parts concerned and shall conform to the applicable ANSI specifications. Multi-purpose lubricants shall be used, where possible.

4.7 Protection of Metals

All metals to be used in the fabrication process shall be surface treated with due consideration for the severity of exposure to which the surface is subjected. The joining of incompatible metals and materials shall be minimized as much as possible and where unavoidable, adequate care shall be taken to prevent any chemical interaction between the materials.

Following fabrications, all low-alloy steel areas shall be painted with one coat of an approved primer followed by one coat of approved sealer to prevent rusting. Exterior steel surfaces, including roof, underframe, underside of flooring, and equipment shall receive a minimum of two coats of primer. Exterior surfaces, except the underframe and underside of flooring, shall then be given a coat of surfacer and a minimum of two coats of synthetic enamel.

Areas exposed to corrosive substances or fluids shall be protected with coatings resistant to those substances or fluids.

All ferrous metal, unless specified elsewhere to be protected by other methods, or as not requiring protection, shall be galvanized by the appropriate methods in accordance with the requirements of ASTM A123 or ASTM A386. Minor damage to galvanized coatings shall be repaired in accordance with MIL-P-21035.

4.8 Piping and Pressure Vessels

Piping shall be seamless copper, stainless steel or precision steel. Piping, valves, fittings, installation methods, and testing shall be in

accordance with ANSI B31.1 and the ASME Boiler and Pressure Vessel Code. Running joints must not be used; unavoidable joints in pipes shall be made in an approved manner. Joints shall be located where they can be easily accessible. Pipes must be adequately supported throughout their length and at connections, and must not interfere with the removal of other components. Copper tubes or pipes shall not be in contact with aluminum parts.

4.9 Thermal and Acoustic Insulation

Thermal insulation materials of the rigid, non-rigid, or spray-on type shall be used. The materials shall not absorb fluids and gases, and shall possess the required properties to meet the noise, vibration and heat loss limits recommended. Installation of insulating materials shall be done in accordance with the manufacturer's recommendations.

Sound damping material used in fabrication of the vehicle shall be resistant to dilute acids, greases, gasolines, aliphatic oils and vermin, and must not support combustion. It shall not be affected by sunlight and ozone, and shall not become brittle with age. Application of this damping compound shall be in accordance with the manufacturer's recommendations.

4.10 Wiring

4.10.1 General

The following standards shall apply to all wiring, including that within enclosures supplied by others.

All wiring shall be at least equal to that specified in the latest revision of the National Fire Protection Association's National Electric Code (NFPA 70), Table 310-16 and Note 8.

Wiring insulation shall meet the flammability and smoke emission requirements of Section 4.3.4.3.

All vehicle wiring connected to a given piece of electrical apparatus shall be insulated for the highest voltage so connected.

Wires operating with potential differences of 50 volts or more shall not be cabled together.

Wiring for any communications and cab signal (if used) shall be done in an approved manner to conform with the requirements established by the Manufacturer of such equipment.

4.10.2 General Purpose Wire and Cable

Except for high temperature applications, all circuits of the vehicle wiring installation shall be connected using general purpose wire and cable. Primary power circuits (if used) shall use wire rated at 1,500 V dc minimum. All other circuits shall use wire rated at 600 V dc.

Conductors shall be annealed tinned copper wire meeting the requirements of ASTM B33. The conductors shall have a minimum stranding conforming to ASTM B172 Class K, for AWG 4/0 to AWG 8, ANSI C7.14 Class K for AWG 10 to AWG 22 and Class L for AWG 24.

Minimum wire size, as related to control and auxiliary circuits, shall not be reduced such that vibration or other causes could produce destruction.

In general, wires for control and auxiliary circuits shall not be smaller than No. 12 AWG, except within equipment enclosures and for special apparatus where special types of wire are recommended for use by the Manufacturers and approved by the Purchaser for inter-connection of the various pieces of equipment.

No. 14 AWG wire, with an approved insulation, may be used for inter-connection of cab signal (if used).

When bundled, No. 16 AWG wire may be used in circuits where the current is low and physical strength is not necessary.

The stranding and nominal O.D. of flexible cables shall be as required for IPCEA Class H.

4.10.3 High-Temperature Wire and Cable

At locations subjected to high temperature, all wire and cable shall be insulated and jacketed with silicone rubber. This type of wire shall not be bundled together or run with any other type of cable. Conductor material shall be tinned copper wire. Class K stranding shall be used for sizes No. 20 AWG to No. 10 AWG, and Class H stranding shall be used for larger sizes.

4.10.4 Communication Wire and Cable

Communication wire and cable shall consist of twisted pairs of not less than No. 16 AWG soft annealed, tinned copper. Each twisted pair shall be shielded with a woven wire shield providing not less than 85% coverage. Shield wire shall be soft annealed, tinned copper.

4.10.5 Conduit and Raceways

All vehicle wiring shall be housed in metal or approved plastic raceways. All plastic materials shall satisfy the flammability and smoke emission requirements indicated in Section 4.3.4. Open metal raceways and their elbows, couplings, nipples, bushings, locknuts, universal joints, expansion joints, and other conduit fittings shall be designed so that the sections can be mechanically and electrically coupled while protecting the wires from abrasion.

Wire in conduit, ducts and raceways shall be free of kinks, insulation abrasions and insulation skinning. Except in most unusual cases, and then only when approved by the Purchaser, no conduit, duct or raceway shall contain more wires than will give a maximum of 40% fill.

Wire shall not be bundled if in a conduit, duct or raceway. Each wire must be capable of being removed for replacement without disturbing other wiring in the enclosure. Where wire is in open areas, bundling shall be permitted.

Pulling compound, if used, shall be non-conductive, non-hydroscopic, non-odorus, and shall not attract vermin.

Flexible conduit shall be aluminum or steel alloy tubing with watertight compression fittings or approved equal. Both inside and outside surfaces shall be protected against corrosion. The flexible metal conduit shall conform to the requirements of UL-1.

Electrical metallic tubing (EMT) shall be fabricated from high-strength aluminum or steel and shall conform to the requirements of ANSI C80.3. Their interior surfaces shall be smooth and free from injurious defects. Fittings for EMT shall be corrosion-protected metal and shall conform to the requirements of UL-797.

Rigid aluminum conduit (if used) shall consist of seamless, rigid, aluminum alloy conforming to ANSI C80.5. Rigid steel conduit shall be mild steel and shall satisfy the requirements of ANSI C80.1.

Conduit, if required in the truck area and approved by the Purchaser, shall be standard weight galvanized steel with threaded fittings. All covers shall be gasketed, using approved materials. Interiors of junction boxes shall be suitably protected by insulating paint against condensation and corrosion. When more than one supplier is used, all fittings which require covers and are of the same size shall be supplied by the same manufacturer.

4.10.6 Junction Boxes

Pullboxes, outlet and junction boxes shall be provided specifically for application with the conduit and cable systems with which they are to be used. Boxes, covers, and fittings of ferrous metal shall be galvanized inside and outside after fabrication.

Exposed exterior boxes shall protect enclosed equipment against splashing water, water seepage, and falling or hose-directed water normally encountered in vehicle operations. Boxes shall be of sufficient size to provide free space for conductors in accordance with NFPA Code 70.

4.10.7 Splicing, Taping & Soldering

Splicing and taping will not be acceptable except in unusual cases where it is unavoidable and then normally only under a controlled process, such as with approved solderless connectors, and only with the approval of the Purchaser.

4.10.8 Terminals

Conductors shall be terminated by mechanical means, using solderless terminals, with crimp-on ferrule or approved equal. Soldered terminals shall not be used, except in specific cases and only when approved by the Purchaser. Multipin Connectors, MIL-C-5015 environmentally protected, or equal, may be used for low voltage dc circuits. Conductors shall be attached to the terminals according to the method prescribed by the terminal Manufacturer. No more than two conductors shall be attached to a single terminal point.

Terminals used on conductors sized No. 10 AWG or smaller shall be of the insulating type and designed to securely grip and hold the insulation on the conductor.

Conductors subject to motion relative to the terminal shall be protected by proper means to eliminate fracture of the conductor at or near the terminal.

4.10.9 Undercar Wiring

All undercar wiring of No. 8 AWG or smaller shall be run in an approved manner in plastic coated metal raceways and wire ducts with removable metal covers of adequate size and approved design, and securely fastened, but easily removable when necessary. The enclosure shall be securely anchored to prevent vibration, rattling or drumming. On leaving such enclosures to enter other equipment, this wiring shall be routed so as to obtain maximum protection from heat, chafing vibration, etc. Additional protection in the form of added insulation shall be used in the exposed areas.

When of adequate physical strength, No. 6 AWG or larger wires may be supported in place at frequent intervals without using any type of enclosure, by using molded rubber cable support blocks. Enclosure openings which are contoured to the shape of the cable and provided with strain relief bushings shall be used. Box connectors shall be the insulated throat type, and strain relief bushings shall be provided with non-metallic end bushings.

When approved by the Manufacturer of the signal equipment (if used), the Contractor may install signal wiring in common ducts with other wiring at battery potential, provided that approved-type separators are used to isolate the signal circuit wiring.

Lead wires to electrical components shall be carried in a wire duct or conduit to a point as close to the compartment as possible. The length of the leads between the end of the duct or conduit to each compartment shall be as approved by the Purchaser.

Wires or cables shall not pass over or through the battery compartment, or, if in conduit or ducts, over the main motor resistors (if used).

Wiring run through the floor must be run in conduit or ducts and may not be run through partitions without suitable bushings being provided at such points of passage.

All wires and cables shall have sufficient slack to prevent breaking or pulling out of bushings or terminals, and a service-ability loop for three reworks of end of wire or cable. Drip loops shall be provided.

All wiring shall be installed in an approved manner to prevent chafing with each other, between wire and interior surfaces, adjacent components in compartments, or against any metallic parts.

4.10.10 Safety of Personnel

The Contractor shall ensure that all metal parts inside and outside the vehicle, including equipment boxes, panels, and test receptacles,which could be contacted by passengers or operating personnel, are properly grounded.

4.10.11 Wire & Terminal Marking

All electrical conductors, whether individual wires or cables, shall be assigned circuit designations for the entire vehicle. The system of designating wires and circuits shall be the prerogative of the Purchaser, who shall acquaint the Contractor with his system prior to any wiring of the vehicle including the layout on the bench.

The individual conductors within any cable shall be appropriately color-coded and full reference to these color codes shall be included on all documents relating to the cables. The Contractor and his suppliers shall adhere to the adopted method of marking and color-coding.

All electrical connections terminals, whether strip type, plug, socket, etc., shall be assigned circuit designations on the basis of the system selected for the entire vehicle, as described above.

The markings shall be of a type that are permanent in nature and readily identifiable after all connections are in place.

5.0 IN-SERVICE SUPPORT

In-service support shall be provided to the Purchaser by the Contractor in the following six areas:

1. Publications
2. Diagnostic Tests
3. Spare Parts Inventory
4. Gauges and Special Tools
5. Training of Purchaser's Personnel
6. Inspection and Acceptance Tests

Details of the support to be provided in each of these areas is described below:

5.1 Publications

The Contractor shall prepare and furnish to the Purchaser the following seven publications:

- Operator's Instruction Manual
- Running Maintenance and Servicing Manual
- Heavy Repair and Maintenance Manual
- Parts Catalog
- Recommended Spare Parts List
- Support Equipment List
- Engineering Drawings

Requirements for each of these documents are described below:

5.1.1 Operator's Instruction Manual.

This manual shall contain all information needed for the optimum operation of the vehicle(s). It shall include:

- General car familiarization material
- Location, function and operation of all controls, gauges, indicators and switches
- Emergency procedures, and
- Trouble symptoms and diagnosis methods.

5.1.2 Running Maintenance and Servicing Manual

This manual shall provide the maintainer, in convenient form, with all information needed for on-vehicle servicing, including:

- lubrication,
- inspection,
- running maintenance and adjustments,
- on-line trouble diagnosis.

Safety precautions shall also be included where applicable.

5.1.3 Heavy Repair and Maintenance Manual

This manual shall contain a detailed analysis of each component of the vehicle so that maintainers can effectively and safely service, inspect, maintain, adjust, trouble-shoot, repair, replace, and overhaul each component and subsystem. Frequency of minor and major overhauls, in terms of operating hours and/or operating miles, shall be provided for those components and major subsystems, where such data are available.

5.1.4 Parts Catalog.

Within the period specified in the Contract Terms and Conditions, the Contractor shall submit to the Purchaser a Parts Catalog which shall enumerate and describe every component with its constituent parts, the vendor's number, the Contractor's number, and the

commercial equivalents. Cutaway and exploded drawings shall permit identification of all parts not readily identified by description. Parts common to different components (for example, bolts and nuts) shall bear the same Contractor's number with a reference to the other components in which they shall be found. Each part or component shall be identified as part of the next larger assembly.

Within the period specified in the Contract terms and conditions, the Contractor shall submit a sample format of the Parts Catalog to the Purchaser for approval. Prior to printing, the approved draft of the Parts Catalog in final form shall be supplied to the Purchaser so that the Purchaser can insert the proper order or control numbers for each part.

5.1.5 Recommended Spare Parts List.

The Contractor shall prepare and submit to the Purchaser a Recommended Spare Parts List. This listing will become a working document to be used by the Purchaser for procurement of spare and replacement parts. The minimum quantity of each spare part required to perform normal maintenance and to maintain the operation of the vehicle shall be shown on this list.

The Recommended Spare Parts List shall group listed parts by subsystems. The listing for each item shall give complete ordering and procurement information for that item. Lead times of long lead-time items shall be specifically noted. Each item listing shall contain at least the following information: item name, description, rating, current price, manufacturer's name, part number, commercial equivalents, and drawing reference number. Items that are common to more than one subsystem shall be suitably cross-referenced.

5.1.6 Support Equipment List.

The Contractor shall furnish to the Purchaser a list of all shop support equipment required to test and maintain the vehicle. Sizes needed, where used, and any other pertinent information shall be included on this list. Support equipment is defined as the tools, test equipment, jacks, jigs, fixtures, hoists, cranes, etc., that are required in order to maintain and operate the vehicle.

5.1.7 Engineering Drawings

The Contractor shall submit engineering drawings showing a complete and comprehensive arrangement of the vehicle. A complete set of reproduceable master engineering drawings shall be furnished, as well as one complete set of prints from these masters. Each set of engineering drawing shall show assemblies, major components, and all subassemblies. Drawings shall include details necessary for the installation, maintenance and repair of all equipment provided. A weight distribution analysis shall be submitted with these drawings.

The Contractor shall prepare clearance diagrams of the vehicle prior to completion of the body design. The diagrams shall include complete outlines of the vehicle, and shall reflect all possible suspension limits due to wear.

5.1.8 Organization of Publications

For all three sets of manuals, (Operator's Instruction Manual, Running Maintenance and Servicing Manual, and Heavy Repair and Maintenance Manual) the following approach shall be used in their preparation. The vehicle shall be treated as a whole and not as a grouping of disassociated parts. The material in all manuals and the Parts Catalog shall be similarly organized and indexed, with a standard numbering system, as approved by the Purchaser.

MIL-M-38784 shall be used as the guideline for format of the manuals, and MIL-M-15071 shall be used as a technical content guideline. All vehicle systems shall be included and all sections shall be subdivided, to the extent required by the subject matter, into the following topics:

(a) General Subsystem Description and Operation.

(b) Block Diagrams.

(c) Signal Flow Diagrams.

(d) Functional Schematics.

(e) Functional Wiring and/or Piping Diagrams.

(f) Troubleshooting Techniques.

(g) Lubrication and Cleaning, including frequency, methods, and commercial identification of recommended materials; component locations and descriptions.

(h) Inspection and Maintenance Standards, including wear limits, settings, and tolerances.

(i) Installation and Removal Procedures.

(j) Test and Evaluation Procedures.

Where practical, standard operating and maintenance information provided by subsystem suppliers may be directly incorporated in its original format. Within the period specified in the Contract Terms and Conditions, the Contractor shall submit for the Purchaser's approval, Tables of Contents and Sample Formats for each manual.

5.1.9 Publication Practices

All seven publications named in Section 5.1 shall be issued for continuous, long-term service. These publications shall be supplied in loose-leaf form and printed on a good grade paper. Punched holes

shall be reinforced with plastic, cloth, or metallic material. Five- or seven-ring binders are acceptable in lieu of reinforced paper.

Pages of pocket-sized manuals shall not exceed 5 inches wide x 7 inches high. All other manuals shall use a nominal page size of 8-1/2 inches wide x 11 inches high.

All covers shall be highly resistant to oil, moisture, and wear, commensurate with their intended uses. Diagrams and illustrations shall not be loose or in pockets but fold-out pages are permitted.

Line drawings shall be reduced in size. The use of a thin, clear plastic coating to protect each page from moisture, dirt and oils shall be considered.

Manuals shall be provided to the Purchaser in the quantities and categories as specified by the Purchaser at least four weeks before delivery of the vehicle:

(a) Operator's Instruction Manual - _____(pocket size).
(b) Running Maintenance and Servicing Manual -_____(pocket size).
(c) Heavy Repair Maintenance Manual - _____
(d) Parts Catalog - _____
(e) Recommended Spare Parts List - _____
(f) Support Equipment List - _____

Changes and revisions to all manuals, lists and drawings shall be provided on a timely basis and shall be in the same style and format as the section they replace. Revisions shall be kept current during the warranty period, and supplied to the Purchaser before or with arrival of altered parts. All publications shall be provided first in draft form for use and

correction during initial training and operational testing. Final printings shall incorporate all corrections made during initial training and operational testing.

5.2 Diagnostic Tests

Diagnostic test equipment and diagnostic test procedures shall be provided by the Contractor as described in this section. Two categories of tests shall be covered:

- Bench tests
- Portable equipment tests

Quantities and types of equipment to be provided for each test category shall be defined by the Contractor (Section 5.1.6).

5.2.1 Bench Tests

Bench test procedures and test equipment shall be supplied for the purpose of testing, troubleshooting, and calibrating electric, electronic, mechanical, and electromechanical components of each vehicle subsystem. Test units shall be specified by the Purchaser so that they are compatible with the Purchaser's maintenance and repair facility. Bench test units shall contain provisions for rapid testing, troubleshooting, and calibration of electronic circuit boards, plug-in relays, sensors, transducers, etc., used in vehicle-mounted systems. Shop-supplied compressed air and electric power may be used for bench tests. Tests shall be designed to cover the full working range of each device. Calibration standards of the vehicle test equipment shall be as high as the original factory calibration standards.

5.2.2 Portable Equipment Tests

When electric drive is used for propulsion, test procedures and test equipment shall be supplied to simulate dynamic system operation of the propulsion system by dry sequencing. These test units shall be portable, of the plug-in type and shall contain all control logic, sequencers, generators, indicators, switches, and coupling devices necessary to provide a thorough check of the propulsion system. These test units shall use low voltage dc and logic control power available from the propulsion control equipment, where possible. Under no circumstances shall a vehicle be capable of being propelled when a test unit is connected to the propulsion equipment. The test circuits shall allow critical control and power circuit simulation and readout so that system status can be determined.

5.3 Spare Parts Inventory

Spare parts shall be supplied by the Contractor based on the Contractor's estimates of reliability and maintainability so that the Purchaser shall have a 90 percent probability of having sufficient spares on hand to sustain operations throughout the warranty period. For the period of time set forth in the Terms and Conditions of the Contract, the Contractor shall ensure that replacement parts be available for purchase from the Contractor or other suitable sources.

5.4 Gauges and Special Tools

The Contractor shall examine the existing equipment and tool inventory of the maintenance and repair facilities of the Purchaser and shall submit to the Purchaser a list of additional gauges required and tools recommended to be purchased to effectively maintain and repair the vehicle.

Any special tools required for maintenance and repair shall be supplied by the Contractor. The quantities shall be consistent with the need to meet high levels of reliability and maintainability.

5.5 Training of Purchaser's Personnel

The Contractor shall provide training programs for the Purchaser's operating and maintenance personnel to insure satisfactory operation, servicing and maintenance of the vehicle. These programs shall include formal and informal instructions with extensive use of slides, models, mock-ups, samples, manuals, diagrams and other training aids. The Contractor shall assume no knowledge of the unique features of the vehicle on the part of the Purchaser's personnel, and shall design the programs to raise the level of knowledge to a degree that is fully adequate for the objective. The Contractor shall assume that the maintenance personnel have the basic skills pertinent to their respective crafts.

As a part of his bid submission, the Contractor shall furnish the Purchaser with details of the training program he intends to provide. These details shall include the hours of classroom and field instruction that will be provided, the qualifications of the instructors, a list of training aids to be used and furnished, and a brief description of the scope of instruction to be covered.

Formal classroom instruction shall be conducted in a suitable classroom furnished by the Purchaser on his premises. Informal field instructions may also be conducted on the Purchaser's property at his direction. The Purchaser shall furnish the Contractor with the number of employees who shall require training.

At the conclusions of the classroom instructions, the Contractor shall furnish to the Purchaser two complete sets of lesson plans, classroom notes, film, slides and tapes used in presenting the courses.

The training program shall include demonstrations of troubleshooting procedures, component replacements, systems calibrations and adjustments, and selected maintenance procedures, such as separation of detachable snow-removal equipment from the vehicle.

5.6 Inspections and Acceptance Tests

Inspection and acceptance tests shall be performed on the completed vehicle as a condition for vehicle acceptance and payment under the terms and conditions of the contract. The three categories of vehicle inspection and tests are:

- Delivery Inspection
- Operation Acceptance Tests
- Snow Fighting Acceptance Tests

Guidelines for performing these inspections and tests are described below and a test procedure for verification of the snow removal rate is given in Appendix A.

5.6.1 Delivery Inspection

After a vehicle is delivered to the Purchaser's site, the vehicle shall not be operated, but shall be thoroughly inspected by both Contractor and Purchaser to determine that it is complete and is not damaged. Any defects, deficiencies or damage that are found shall be duly recorded, and the Contractor shall make the necessary corrections as soon as practical. Delivery Inspection shall be performed within 15 days after vehicle delivery.

5.6.2 Operation Acceptance Tests

These tests shall be performed by the Contractor and witnessed by the Purchaser. The test site shall be mutually agreed to by the Contractor and the Purchaser, and these tests shall be performed within 30 days after Delivery Inspection.

The Operation Acceptance Tests shall demonstrate that the vehicle meets all the performance requirements except those related to snow fighting abilities. These tests shall include the following:

- Vehicle weigh-in
- Propulsion and braking tests.
- Clearance tests.
- Coupling/towing tests.
- Center lifting device tests (if applicable).

Vehicle weigh-in shall record the vehicle gross weight for the baseline configuration, both with empty and full fuel tanks. The weight on each truck or axle shall also be recorded to verify the weight distribution analysis supplied by the Contractor.

Propulsion and braking tests shall be run to verify the performance of these systems and the behavior of the diesel engine, drive system, hydraulic and air brake systems, etc. under the complete envelope of specified operating conditions of tractive effort, running speed, and braking rates. Observed values of acceleration, braking rate, air pressure, hydraulic pressure, etc., shall be recorded and compared to expected values to verify proper running of the vehicle.

Clearance tests shall be performed on the Purchaser's rail network to verify that the vehicle is capable of traveling over the entire system, including yard and shop track, clearing restrictions such as short radius curves, station platforms, tunnels and bridges, without lateral or under-carriage interference. Vehicle speeds shall be on the posted speeds or maximum vehicle speed, if lower than the posted speed. Snow removal equipment shall be in the positions that provide the minimum clearance for these tests.

Coupling towing tests shall be performed to demonstrate that the vehicle can be coupled to another vehicle and towed. Towing by the vehicle shall also be demonstrated, but only where this capability is a vehicle performance requirement.

Center lifting device tests shall be performed for rail mounted "jet" blower and rail/highway vehicles to verify that the center lifting device operates properly to raise and lower the vehicle under cab control. Clearance of the raised vehicle above the third rail shall also be verified.

5.6.3 Snow Fighting Acceptance Tests

These tests shall be performed by the Contractor and witnessed by the Purchaser. The test site shall be mutually agreed to by the Contractor and the Purchaser, and these tests shall be performed during the winter season.

If, within a predetermined time after delivery and during the winter season, there is insufficient natural snow accumulated at the test site to perform the Snow Fighting Acceptance Tests, then the Contractor, with approval of the Purchaser, shall arrange to either have snow brought into the test site, or shall make artificial snow in sufficient quantities to perform these tests.

The Snow Fighting Acceptance Tests shall demonstrate that the vehicle meets all the snow fighting performance requirements, and shall include:

- Snow removal rate test
- Snow removal clearance profile test
- Snow discharge tests
- Third rail (or catenary) snow/ice removal test (if applicable)
- Front-end broom/plow tests (if applicable)

The snow removal rate test shall be performed to verify that the vehicle can clear the right-of-way at the specified rate (measured in tons/hour) for any conditions of snow density, snow depth and operating temperature within those ranges described in Section 3.1. Details of this test procedure are provided in Appendix A.

A snow removal clearance profile test shall be performed to verify that the cross section of a cleared test section conforms to the clearance profile template specified by the Purchaser. Equipment modifications shall be made, if required, until a cleared test section conforms to this template profile.

Snow discharge tests shall be performed to verify that the discharged snow can be properly directed under the cab control to achieve the specified minimum and maximum values of throw range. The achievable azimuth angle of the discharged snow to either side of the forward direction shall also be measured, for comparison to specified values as the azimuth angle is varied under cab control.

Third rail (or catenary) snow/ice removal tests shall be performed to verify the operation and effectiveness of third rail brooms and/or

ice scrapers, or catenary ice scrapers, if any of this equipment is provided with the vehicle.

Front-end sweeper brooms and/or front-end V-shaped or pusher-type plows shall be tested to verify their performance and effectiveness, if any such equipment is provided with the vehicle.

6.0 WARRANTY

The warranty shall direct the performance requirements of the equipment and the responsibility of the Contractor in meeting these requirements. The warranty shall define a deficiency in a component or sub-system and direct the specific means by which the contractor shall correct the deficiency and the means of reimbursement to the Purchaser should costs be incurred.

6.1 Warranty Coverage

The warranty period for the vehicle(s) and sub-systems should commence on the day of acceptance of the vehicle(s) by the Purchaser, or if the vehicle(s) is/(are) to be used seasonally, the warranty shall commence within a specified time frame from the day of acceptance by the Purchaser.

6.2 Warranty Period

The general warranty for the vehicle(s) should be for a period of two (2) years from the date of acceptance by the Purchaser or if the vehicle is to be used seasonally within a specified time frame from the day of acceptance of the vehicle(s) by the Purchaser.

The warranty for the car body and frame should be for five (5) years from the date of acceptance of the vehicle(s) by the Purchaser or if the vehicle(s)/(are) to be used seasonally, within a specified time frame from the day of acceptance of the vehicle(s) by the Purchaser.

7.0 RAIL-MOUNTED "JET" BLOWER

7.1 Performance Requirements

The performance requirements or functional capabilities required for a rail-mounted "jet" blower snow removal vehicle are described below.

7.1.1 Functional Capabilities

Functional capabilities required for a rail-mounted "jet" blower snow removal vehicle are as follows:

- Self-propelled, in either direction of travel with an on-board power source. Capable of travel at speeds up to _____ mi/hr with "jet" blower Off. Capable of travel up a five-percent grade, with "jet" blower On and at maximum throttle, at a speed of _____ mi/hr.

- Continuous operation while removing snow, without need for fuel or maintenance, for at least 6 hours.

- Capable of being towed from either end, at speeds up to _____ mi/hr.

- Capable of traveling over the entire rail network of the Purchaser, including yards and shops..

- Capable of removing snow and ice both in the yards and along the right-of-way. Snow removal rate shall depend on depth and consistency of snow/ice, but shall not be

less than 300 tons/hr. Snow removal profile shall be in conformance with the Purchaser's clearance template.

- Capable of removing snow and ice from the third rail.

- Capable of reversing direction of forward travel, by means of a center lifting device.

- Capable of carrying a seated crew of two in the cab, with all necessary tools, and controlling all operations from the cab.

7.1.2 Operating Modes

The "jet" blower vehicle shall have four operating modes as follows:

- Travel Mode
- Snow Removal Mode
- Turning Mode
- Tow Mode

Operations in each mode are described below.

Travel Mode - The vehicle shall be capable of independent, self-propelled travel at forward speeds up to ____ mi/hr in this mode. Travel in reverse shall also be possible at speeds up to ____ mi/hr.

Snow Removal Mode - The vehicle shall be capable of independent, self-propelled travel at forward speeds up to ____ mi/hr in this mode Travel in the reverse direction shall also be possible.

Turning Mode - The parked vehicle shall be raised above the rails with a center lifting device, rotated a half-turn (manually), then lowered onto the rails in this mode. This means of reversing the direction of forward travel shall be operative only when:

- the vehicle is uncoupled
- the propulsion drive is in Neutral
- the brakes are applied
- the "jet" blower is Off.

Interlocks shall prevent use of the center lifting device unless the last three conditions are met.

Interlocks shall also prevent the vehicle from being propelled under its own power unless the center lifting device is in the fully retracted position.

The center lifting device shall raise the vehicle sufficiently so that when rotated it swings out above the third rail with a vertical clearance of at least three inches. A latch-up device shall lock the center lifting device while it is in the fully raised or lowered position.

Tow-Mode - The vehicle shall be capable of being towed by another vehicle with towing means at either end of the vehicle. The diesel engine shall be On, where possible, to provide auxiliary power for pneumatic brakes and the "jet" blower shall be turned Off. The center lifting device shall remain retracted while in this mode.

7.1.3 Snow Removal Capacity

The "jet" blower vehicle shall be capable of removing snow of any consistency from the yards or right-of-way. Width of the cleared swath shall be specified by the Purchaser. Average depth of snow shall be as high as two feet, with three foot drifts. The average rate

of snow removal shall be at least 300 tons/h. The "jet" discharge nozzle shall be moveable both side-to-side and up or down, by means of cab-operated controls.

7.1.4 Propulsion and Braking

In the travel mode, the vehicle shall be capable of accelerating at a rate of 0.75 mi/hr/sec on level, tangent track, when fully loaded with fuel and a crew of two, with the "jet" blower Off.

In the snow removal mode, the propulsion shall provide adequate tractive effort at the rails to overcome jet engine thrust and gravity forces so that the vehicle shall be capable of traveling up a five percent grade at a minimum speed of _____ mi/hr.

Travel speed requirements for each mode of operation shall be specified by the Purchaser.

Pneumatic brakes shall be applied on all four wheels. Two braking rates shall be provided:

- Service brake rate of 2.5 mi/hr/sec.
- Emergency brake rate of 3.0 mi/hr/sec.

Braking action shall be equally effective in either direction of travel, and at least two of the four brake units shall be of the fail-safe type.

In the event of a braking component failure, at least half of the desired braking rate shall be achieved. Brakes shall be operational in all modes except the Turning Mode.

An independent parking brake shall be provided and shall act on at least one axle. It shall be capable of holding a vehicle fully loaded with fuel when parked on a five-percent grade.

Means shall be provided for emergency release of the brakes, from within the cab, in the event that the brakes are applied due to an air system failure. This feature allows a vehicle to be towed after an air brake failure.

7.1.5 Coupled Operations

The "jet" blower vehicle shall be capable of being towed from either end. When towed, the diesel engine shall be On, where possible, to provide auxiliary power for braking, and the power drive shall be in Neutral. The "jet" blower shall be Off and the center lifting device in the retracted position.

Travel speeds shall not exceed _____ mi/hr or the posted speeds, if lower, in this mode.

7.2 Design Features

Design features to be specified in order to purchase a "jet" blower vehicle to meet the performance requirements of Section 7.1 are described below:

7.2.1 Frame

The chassis frame shall be constructed of welded steel channel, rigidly braced and reinforced. Material strength and section modulus for each frame member shall be selected to avoid permanent

deformation or operational problems due to elastic deformations when loads expected under intended service are applied.

The vehicle frame shall be provided with the following features:

- A means shall be provided at each end for attachment of a tow bar to permit pushing or pulling of the vehicle by another vehicle. Details of the towing means shall be provided by the Purchaser. The towing bar shall be provided and stored in the cab when not in use.

- Jacking pads shall be provided at each lower corner of the frame, of suitable size and thickness for rerailing purposes.

- Lifting lugs or baling attachments of adequate size and strength shall be provided so that the vehicle can be lifted by these lugs, if required. They shall be located on the frame so that "balanced" lifting by a crane or hoist can be obtained.

7.2.2 Suspension

The vehicle shall have a wheel/axle configuration of two axles and four wheels.

The suspension system for each of the two axles shall be of adequate strength to sustain the gross axle weight of a vehicle fully loaded with fuel without overload or permanent set, for all combinations of load and use.

The active spring suspension system for each axle shall provide adequate deflection so that each wheel can rise or drop as required by varying track conditions. However, sufficient rigidity shall be provided so that the vehicle body profile remains inside the dynamic outline for all conditions of load and use.

7.2.3 Wheels, Axles and Bearings

Wheels shall be solid cast steel 20 inches in diameter. The tread and flange profile shall be specified by the Purchaser. The AAR Standard wheel gauge dimensions and tolerances shall be used, unless otherwise specified by the Purchaser.

Axles shall be made of solid alloy steel, with a minimum diameter of 4 in.

Tapered roller bearings for each wheel shall conform to AAR standards. Service life shall be based on maximum axle loads and rated for a bearing life (B-10) of 300,000 miles.

Wheels, axles and roller bearings shall be mounted using pressures and fits as specified in the AAR Wheel and Axle Manual.

Wheels, axles and bearings shall all operate without excessive vibration, wobble or eccentric action at all speeds up to 40 mi/hr or the maximum speed at which the vehicle shall be used, if greater.

7.2.4 Brakes and Pneumatic System

The vehicle shall be equipped with pneumatic brakes to provide the braking rates specified in Section 7.1.4. Braking forces shall be applied by individual units to the treads of all four wheels, with fail-safe braking on two of the four wheels.

The braking system shall consist of the following major components:

- Air compressor
- Air reservoir tank
- Engineer's valve
- Brake actuators and tread brake shoes (4)
- Emergency stop valve (parking brake)
- Emergency hand pump (hydraulic)
- "Dead man" foot valve

These components shall be connected with suitable air lines, check valves, etc., and properly adjusted to obtain the desired performance. An air horn shall also be supplied directly from the air reservoir tank and a tank pressure gauge shall be installed on the cab console.

Details for the major components are described below:

The air compressor shall be mechanically driven from the diesel engine output. It shall be of a type approved by the Purchaser, and equipped with a dessicant air dryer. The nominal discharge pressure shall be 130 lb/in^2 and the capacity shall be adequate to fully charge the air reservoir tank in an interval of _____ minutes on a cold start. The compressor shall be equipped with safety valves and a regulating governor to maintain the pressure in the air reservoir within a prescribed range.

The air reservoir tank shall have a volume at least eight times the combined displacement volume of the four brake actuators. It shall be of welded steel construction and designed for a nominal pressure of 150 lb/in^2. Wall thickness shall be based on a factor of safety of eight or greater. The tank shall be fitted with:

- An automatic drain cock equipped with an electric heating element thermostatically controlled placed at the lowest point.
- A safety relief valve - set to 160 lb/in^2.

Design and pressure testing shall conform to provisions of the ASME Boiler and Pressure Vessel Code.

The Engineer's valve shall be of an approved design and conveniently located on the console in the cab. It shall not be used for a parking brake. The following valve positions shall be provided:

- Emergency brake
- Service brake (minimum to maximum)
- Lap
- Release
- Handle off

The Engineer's valve handle shall be capable of being removed from the valve stem in the handle off position. The handle off position shall be in a fail safe position of the valve quadrant.

Four brake actuators shall be provided, one for each wheel. These actuators shall be designed for long life with minimum maintenance. Two types of brake actuators shall be used:

- Fail-safe brake actuators - (spring applied/air released)
- Service brake actuators - (air applied)

Automatic slack adjusters shall be provided on all four brake actuators. Similar types of brake actuators shall be placed in diagonally opposite locations (e.g., left-front and right-rear).

An emergency stop valve shall be provided and be so located so as to insure ease of accessibility, maintenance and resetting. This valve shall also serve as a parking brake. The parking brake shall be capable of holding a fully fueled vehicle while parked on a five-percent grade.

An emergency hand pump shall be provided to unlock the two fail-safe brakes, in the event that air pressure is lost. This hand pump shall apply hydraulic pressure to release both fail-safe brake actuators in order that the disabled vehicle may be towed.

A "dead-man"emergency release foot valve shall be provided. Operation of this foot valve shall enable the emergency hand pump to be used to release the fail-safe brake in order that the vehicle may be towed in the event of a loss of air pressure in the braking system. When this foot valve is released, the hydraulic pressure provided by the hand pump shall be removed, reapplying the brakes.

7.2.5 Diesel Engine

A diesel engine shall provide the on-board power source for vehicle propulsion, all auxiliary equipment not battery-powered, and the alternator. This engine shall be rated or sized to provide adequate torque and horsepower for all needs including the propulsion acceleration requirements (Section 7.1.4), with a 25 percent margin on horsepower.

A 2-stroke, fuel injected, water-cooled diesel engine suitable for rail service shall be provided. All standard equipment for this engine for rail application shall be included unless otherwise indicated, whether or not that equipment is specified herein.

The diesel engine shall be certified to operate on Nos. 1 and 2 fuel. As delivered, it shall be tuned for use with No. ____ fuel.

The engine shall provide sufficient power for propulsion and all equipment functions when used in the extreme environments described in Section 3.

The engine shall be mounted on the vehicle with isolation pads.

The engine shall be capable of starting within 10 seconds or two-thirds of the cranking system's time rating, whichever is shorter.

The engine shall be equipped with replaceable cartridge-type oil and fuel filters.

The engine cooling system shall be of sufficient capacity to permit continuous operation of the engine at full load conditions with ambient temperature as high as 110° F.

An ethylene glycol permanent-type anti-freeze with rust inhibitors satisfactory for winter and summer services shall be added to the coolant in sufficient concentration to provide protection to -40° C).

The engine shall be equipped with a single-stage dry-type air cleaner. The cartridge shall be replaceable and have a condition indicator. The air cleaner shall have an automatic moisture and dust evacuator, and be designed so as to prevent freeze-up during winter snow clearing work.

The engine shall be equipped with a 120 Volt engine block heater to facilitate cold weather starting. The electrical connection for the engine block heater shall be conveniently located, of weatherproof design, and shall be of the male recessed type. At the discretion of the Purchaser a direct hot water engine block heater may be provided in place of the 120 Volt engine block heater.

The engine exhaust system shall be equipped with a special low-noise muffler and any additional devices required to conform to provisions of the Clean Air Act of 1970. The tail pipe shall be vertical, located at the top of the vehicle, and protected by a rain cap. The exhaust system shall accommodate the thermal expansion and vibration caused by normal use, and shall be located so that its heat shall not adversely affect nearby equipment; safety guards shall be used to protect personnel, if required.

The engine shall be equipped with a 12 Volt alternator and voltage regulator for charging the battery. Alternator current rating shall be _____ Amperes.

The engine radiator and fan shall be enclosed in a well ventilated housing fabricated from 16 gauge sheet metal over an adequate support structure. Clearances inside the engine cabinet shall be adequate for all routine engine maintenance and replacement. Doors shall be large enough to permit easy access. They shall be hinged to open wide and shall not be less than 18 gauge steel. Non-skid type open grating shall be provided in the area near the engine enclosure.

The engine shall be started, stopped, and throttle-controlled from the cab. A suitable ignition key shall be required to operate the diesel engine.

Engine oil pressure and coolant temperature, engine speed and battery charging current shall all be shown on indicators, conveniently located

on the cab console. Means shall be provided for automatic engine shutdown, should the engine oil pressure be too low or the engine coolant temperature be too high. Annunciators shall be installed on the cab console to alert the operator when these shutdowns occur.

7.2.6 "Jet" Snow Blower

The "jet" snow blower shall consist of the following major components:

- Aircraft-type jet engine
- Discharge nozzle
- Two-axis gimballed mount
- Controls

The "jet" engine shall be equipped with a 2-stage fuel filter consisting of a 60 micron primary and a 10 micron secondary.

The "jet engine shall be equipped with a hydraulic starter motor which is operator- controlled by a hydraulic valve in the cab.

The "jet" engine shall be equipped with a removable inlet screen to minimize ingestion of sand.

The "jet" engine shall be equipped with an automatic shutdown feature; the engine shall be shut down should the tailpipe temperature exceed 800° F (427° C), and an annunciator shall be provided on the cab console to alert the operator that an automatic shutdown has occurred. A shut-down test shall also be provided so that the operator can verify that this feature is in good working order.

The "jet" engine fuel consumption rate at minimum throttle setting shall not exceed 180 gal/hr.

When the "jet" engine is run at Maximum throttle setting, and the diesel engine is also running at nominal speed, the "A" weighted sound level, measured at a distance of 24 ft to either side of the vehicle, shall not exceed 106 dBA.

The discharge nozzle shall be fabricated of sheet metal and shaped to direct the exhaust gases towards the rails. This nozzle shall be detachable from the "jet" engine housing and have an exit width of at least ____feet.

"Jet" engine exhaust gasses five feet downstream of the discharge nozzle shall have a minimum temperature of 482° F (250° C) and a minimum velocity of 650 mi/hr when the jet engine throttle is set to Maximum.

The gimballed mount (two-axis) shall support the jet engine and attached discharge nozzle so that the nozzle axis is aimed forward and is directed generally downward. Cab-operated controls shall direct hydraulic actuators on the gimbal mount to "point" the longitudinal axis of the nozzle. The lateral swing of the nozzle shall be 7 degrees to either side from the forward direction. The vertical swing of the nozzle shall be 22 degrees so that it can tilt from "straight-ahead" to a depression angle of 22 degrees. When fully depressed, the nozzle exit shall clear the rails by a vertical distance of at least _____inches.

The "jet" engine controls shall be conveniently located on the cab console. These controls are:

- "Jet" engine hydraulic starter valve
- "Jet" engine throttle control
- Nozzle hydraulic pointing controls

"Jet" engine instrumentation shall include:

- Fuel pressure gauge
- Engine tachometer
- Engine temperature gauge
- Engine oil pressure (gauge and light)
- Engine fuel filter replacement (light on when filled)

An hour meter shall operate to record the cumulative running time of the "jet" engine. It shall be conveniently located in the cab.

7.2.7 Cab

The vehicle shall be furnished with a fully enclosed weather-tight operator's cab that contains a console unit and all of the controls, switches, instruments and annunciators necessary for the complete operation of the vehicle. The cab shall have sufficient seating capacity for at least one other crew member, in addition to the operator. The cab structure and skin shall be of steel, and it shall have an entry door in the rear, accessible by a rear platform and steel steps with appropriate hand rails. The cab door shall have a suitable latch and lock.

The cab shall be mounted on the vehicle structure high enough for good visibility, and insulation shall be added in the walls to reduce cab noise and meet cab heater requirements. The cab roof shall be rounded or truncated on both sides for increased tunnel clearance, and the cab shall be mounted on the vehicle frame with isolation pads.

All cab windows except for the windshield shall be laminated safety sheet glass 3/16 in. thick. The cab windshield shall be laminated safety plate glass 1/4 in. thick. Windows shall be located on all four cab walls, including a window in the door. The side windows shall be of the two-section type, vertically split, with each section allowed to slide horizontally. Each side window shall be designed to provide an emergency exit for the crew. The side windows shall lock from the inside.

The windshield and the rear window shall be equipped with suitable windshield wipers. Ice shields and /or rubber-coated wiper blades shall be used to prevent ice-up in severe winter storms. All wipers shall be pneumatically driven with individual variable-speed controls, conveniently located. Windshield washers shall be installed near each of the windshield wiper units. These washer units shall be fed from one fluid reservoir which shall be conveniently located and easily refillable from inside the cab, and controlled by buttons on the control console. The windshield and rear window shall also be equipped with electric defogger units attached to their inside surfaces and controlled by a switch (with indicator light) located on the cab console.

The cab shall be provided with a diesel-fueled heater. This heater shall be sized or rated to provide adequate heating to maintain a cab temperature of at least 55° F under the most severe weather conditions (Section 3.1). The cab heater shall be provided with the following features:

- The heater shall use a fuel feed solenoid to supply diesel fuel to a carburetor and burner head. A blower motor with integral fan shall circulate cab air through the heater unit.

- Fresh air for combustion shall be taken from outside the cab and the combustion products vented outside the cab.

- The heater shall be controlled from inside the cab by convenient switches. Indicator lights shall show that:

  - The heater is On.
  - The burner is On or being purged.

  A thermostat to control cab temperature shall be provided.

- The heater shall use a 12 Volt dc supply, which shall operate the igniter devices, ignition pack fuel solenoid, and blower motor.

- The heater shall be provided with a tilt switch for automatic shutoff if the vehicle should overturn.

The cab shall be equipped with ventilators to ensure an adequate supply of fresh air. They shall be easily opened from inside the cab, as needed.

A sun visor, of a type and of a material as approved by the Purchaser shall be provided for the cab windshield and shall be located as approved by the Purchaser. It shall be approximately _____ inches high and shall cover the width of the windshield glass. The visor shall be supported over its full length by a stainless steel rod and it shall be fully and readily adjustable vertically to the height of the windshield. Provisions shall be made for the rotation of the visor vertically and horizontally.

The cab shall be equipped with a covered tool box as approved by the Purchaser. The tool box cover shall be provided with an approved hasp and lock.

The cab shall be equipped with a ceiling-mounted dome light, instrument panel back lighting, and a portable map light on a six-foot coiled extension cord, all controlled at the console. The dome light and the instrument lighting shall have integral full-range dimmer switches for improved night visibility.

The cab exterior shall be equipped with four headlights - two front and two rear. They shall be of the halogen, 12 Volt automotive type, and mounted so that they can be aimed and adjustable from the outside and set to illuminate a person of average height standing on the tracks at a distance of 500 feet, and wearing dark clothing and shall be accessible from outside the vehicle for replacement. The controls for these lights shall be located on the cab control panel; they shall be operated in front and rear pairs using two switches. High/low beam switches shall be provided. These switches shall be either foot operated or by toggle located on the cab console.

The cab exterior shall be equipped with marker lights. The number used, their size, color and their exact placement shall be specified by the Purchaser. Marker light fixtures shall be of impact-resistance plastic and shall be easily accessible from the outside for lamp replacement. Control shall be with a single switch on the cab console.

The cab exterior shall be equipped with a rotating, amber beacon light mounted on the cab roof and operated by a switch on the control panel.

The cab exterior shall be equipped with a pair of sealed beam floodlights suitable for outdoor use. Each floodlight shall be mounted on the outside of the cab wall just below the roof - one in the right front corner and the other in the left rear corner. Each floodlight shall be manually aimed from inside the cab, using a remote linkage handle with an integral on/off switch.

The cab exterior shall be equipped with a pneumatically operated dual horn mounted outside the cab and actuated by an operator's horn pedal or button on the cab console. The dual horn shall be provided with snow covers that can be installed to prevent snow ingestion in the horn tubes.

The battery shall be a 12 Volt lead acid type with a _____ ampere-hour rating. The battery shall be located outside the cab in a well-ventilated and protected enclosure. Access to the battery for maintenance and replacement shall be convenient. Battery installation shall be approved by the Purchaser.

The cab shall be equipped with a heavy-duty battery cut-off switch. Electrical protection shall also be provided for each electrical circuit with a panel of resettable circuit breakers of approved design. These circuit breakers shall be heavy-duty, vibration proof, of proper capacity with a magnetic-type instantaneous trip. These breakers shall clearly show "closed" and "open" positions, shall have respective current ratings clearly and permanently marked, and shall be front-removable. Panel-mounted, permanent name plates shall identify the circuits each circuit breaker controls.

The operator's seat shall be designed so as to provide satisfactory comfort and be so located as to provide the operator with good visibility and convenient reach to operating equipment. Provisions shall be made for the vertical adjustment of the seat from a minimum height of ____ in. to a maximum height of ____ in. Means shall also be provided for adjustment of pitch of the seat and the back, in addition to a forward-and-backward adjustment of at least 4 in. The seat shall be upholstered with self-extinguishing neoprene foam and covered with a heavy-duty vinyl fabric of approved color. Both foam and cover shall meet all the requirements for flammability, smoke emission and toxicity as specified in Section 4.3.4. The second cab seat may be a wall-mounted fold-up type to prevent crowding in the cab. The upholstery and fabric materials for this seat shall be the same as for the operator's seat.

The cab shall be equipped with all the necessary instruments, gauges, annunciators and controls so that a single operator can drive the vehicle and operate the "jet" blower. Cab general layout of seating, controls, consoles, etc., shall be for convenient use in accordance with good human factors practices. The Department of Defense document MIL-STD-1472-C (Issued 2 May 1981), "Human Engineering Design Criteria for Military Systems, Equipment and Facilities" shall be used as a guide.

7.2.8 Fuel Systems

The vehicle shall be equipped with three fuel tanks, all of welded steel construction. Two identical larger tanks shall hold fuel for the "jet" blower while the smaller tank shall hold fuel for the diesel engine. All fuel tanks shall be located to preclude contact with the third rail and shall be protected to prevent damage from a low-speed vehicle impact.

Each of the larger fuel tanks shall have a capacity of 550 gallons. They shall be located forward of the cab and connected so that they will drain and fill together. If the fuel tanks are installed within the line-of-sight of the operator, the top forward corner of each tank shall be truncated to improve forward visibility from the cab. A ladder shall be attached to one tank to facilitate refueling.

The filler opening located at the top of each tank shall have a minimum internal diameter of 2 in. A removable strainer and a hinged filler cap suitable for switch locks or common padlocks shall be provided. These tanks shall be vented in accordance with best current practices.

The smaller fuel tank shall have a minimum capacity of 25 gallons, suitable for 10 hours of diesel engine operation. The smaller tank shall be located in a convenient location for filling, yet not close to the third rail or other electrical sources. The filler opening located at the top of this tank shall be of a similar design as the filler openings for the two larger tanks.

An oil-fired hot water heater with immersion coils located in each of the three fuel tanks shall be provided to facilitate cold weather start-ups. This heater shall be approved by the Purchaser and installed in a well-ventilated, protected location outside of the cab. Heater control shall be from the cab console.

A fuel transfer pump of approved design and capacity shall be provided to facilitate loading of the three fuel tanks from fuel drums located at ground level. Pump capacity shall be adequate to transfer all the fuel in a _____ gallon drum in no more than _____ minutes.

7.2.9 Hydraulic Propulsion Drive

The vehicle shall be equipped with hydraulic (hydrostatic) propulsion to drive both axles for a vehicle speed range of 0 mi/hr to 30 mi/hr. The following major components shall be used for this drive:

- Hydraulic pump
- Hydraulic motors (2)
- Diverter valve
- Booster valve
- Control valve
- Brake actuator release cylinders (2)
- Hydraulic reservoir

These components shall be connected with suitable hydraulic lines, check valves, relief valves, filters, tees, etc. to obtain the desired performance. The "jet" nozzle tilt and swing actuators, as well as the center lifting device and the "jet" starter motor shall also be supplied by this hydraulic pump.

Details of these major components are described below.

The hydraulic pump shall be provided to pressurize the hydraulic system. It shall be driven by the diesel engine through an integral clutch. This pump shall be of the fixed-vane two-chamber type and have a nominal total flow rate for these chambers of _____ gal/min. The pump shall be located near the diesel engine, and the pump clutch handle shall be easily accessible.

Two identical hydraulic motors shall be provided to drive the forward and rear axles through short sprocket chain drives. These motors shall be of the fixed vane type and shall be directly driven in either direction by the hydraulic pump. No transmission shall be required.

A diverter valve or series/parallel valve shall be provided for the operator to alter the hydraulic system configuration of the two propulsion motors. When this valve is set in one position, both motors shall be connected in parallel, and maximum torques developed. When this valve is set in the second position, these motors shall be connected in series, and smaller torques developed. The diverter handle shall be located inside the cab and easily accessible to the operator.

A booster valve shall be used to alter the net flow rate by changing the hydraulic configuration near the 2-chamber pump. When this valve is in one position, the full pump output from both pump chambers shall be supplied to the hydraulic motors and actuators. When this valve is in the second position, the output from the larger chamber shall be bypassed back to the hydraulic reservoir, reducing the pump net capacity. This booster valve shall be located inside the cab and easily accessible to the operator.

A control valve shall be provided for the use of the propulsion drive. This valve shall have three positions:

- Forward
- Reverse
- Neutral

This control valve shall be located inside the cab, conveniently located for the operator, and may be part of a bank of control valves used to operate all of the hydraulically actuated devices on the vehicle.

An interlock shall prevent operation of the propulsion drive in either Forward or Reverse unless the center lifting device (Section 7.2.10) is in the fully retracted position.

Brake actuator release cylinders (Hydraulic-type) shall be provided for emergency release of each of the two fail-safe brake actuators, in the event of a loss of air pressure. These cylinders shall be of an approved design and be located so they operate to release the spring-applied brakes when they are locked up. These brake release cylinders shall be manually actuated from inside the cab by use of a suitable emergency hydraulic hand pump. A "dead-man" foot valve shall also be operated for the emergency release of these brakes, so that brakes may be rapidly reapplied, if necessary, by a release of this foot valve.

A hydraulic reservoir or tank shall be provided of sufficient capacity to supply all the hydraulic equipment on the vehicle. It shall be of welded steel construction and provided with approved means for filling and venting. Magnetic drain plugs shall be provided at the bottom of the tank, and relief valves, check valves and intake and suction filters shall be provided as necessary.

Tank design and tank pressure testing shall conform to provisions of the ASME Boiler and Pressure Vessel Code.

A temperature sensor shall be mounted in the hydraulic reservoir to send hydraulic fluid temperature signals to an annunciator conveniently mounted on the cab console.

7.2.10 Center Lifing Device

The vehicle shall be equipped with a center lifting device attached to the underframe for the purpose of reversing the direction of forward travel of the vehicle, when desired. A hydraulically actuated cylinder shall be activated by the operator to extend the base of the device downward from its fully retracted position, so that the base of the device rests, by means of support brackets, on the running rails, and supports the entire vehicle in a balanced state.

The vertical stroke of the center lifting device shall raise the vehicle above the rails sufficiently to provide a minimum clearance of 3 inches above the third rail when the vehicle swings out for a half-turn rotation.

The center lifting device shall provide a low friction bearing for easily rotating the raised vehicle about the vertical axis. Vehicle rotation shall be possible only after the center lifting device has elevated the vehicle to the fully-raised position.

The center lifting device shall provide sufficient lateral support to operate in a proper manner despite any mass unbalance about the lifting center caused by the design of the vehicle, crew movement, or the condition of the fuel tank loading.

The center lifting device shall be provided with a limit switch to sense when it is in the fully lowered or the fully retracted positions. A backup

latching system shall lock up the center lifting device when it is turned Off in either the full-up or full-down position. A cab control console annunciator shall indicate when this device is in the fully retracted position; a second annunciator shall indicate when this device is in the fully lowered position. The "fully-retracted" annunciator signal shall also be used as a propulsion interlock (Section 7.2.9) to prevent vehicle motion unless the center lifting device is fully retracted.

The center lifting device shall be provided with a rotation sensor and an annunciator on the cab console to indicate when the rotating vehicle is aligned to the rails. The center lifting device shall be operated with a hydraulic control valve conveniently located inside the cab. This valve shall have three positions.

- Raise
- Lower
- Off

Interlocks shall be provided so that the center lifting device cannot be operated unless:

- The "jet" blower is Off, and
- The propulsion drive is in Neutral
- The parking brake is Applied

The center lifting device shall be provided with an emergency hand pump (operated in conjunction with a "dead-man" foot pedal) to complete raising and/or lowering the vehicle in the event of a loss of hydraulic pressure. (This hand pump may be the same hand pump used for emergency release of the brakes in the event of a loss of air pressure).

7.2.11 Cab Equipment and Controls

The cab shall be equipped with all the necessary instruments, gauges, annunciators and controls so that a single operator can drive the vehicle and operate the "jet" blower. Cab general layout of seating, controls, consoles, etc., shall be for convenient use in accordance with good human factors practices. The Department of Defense document MIL-STD-1472-C (Issued 2 May 1981), "Human Engineering Design Criteria for Military Systems, Equipment and Facilities" shall be used as a guide.

The following dial gauges shall be provided in the cab:

-	Speedometer	mi/hr
-	Odometer (with trip meter)	mi
-	Clock	hr, min
-	Air pressure (brake pressure)	lb/in^2
-	Diesel fuel level	gal
-	Diesel engine tachometer	rev/min
-	Diesel engine oil pressure	lb/in^2
-	Diesel engine coolant temperature	°F
-	Diesel engine hour meter	hr/min
-	Battery ammeter	Amp
-	"Jet" blower fuel level	gal
-	"Jet" blower tachometer	rev/min
-	"Jet" blower oil pressure	lb/in^2
-	"Jet" blower temperature	°F
-	"Jet" blower fuel pressure	lb/in^2
-	Hydraulic fluid temperature	°F
-	Hydraulic pump discharge pressure	lb/in^2
-	Hydraulic pump inlet pressure	lb/in^2

The following devices shall be provided in the cab for the operator's control of the vehicle and all vehicle equipment:

- Diesel engine throttle (speed control) (cont. low-to-high)
- Diesel engine shutdown button (on/off)
- Diesel engine emergency shutdown button (on/off)
- Diesel engine keyed ignition/start switch (on/off/start)
- Diesel engine cold start button (if used) (on/off)
- Engineer's valve (air brake valve) (Emerg/Serv/Lap/Release)
- Emergency stop valve/hand brake (on/off)
- Emergency hand pump (hydraulic) (manual)
- Dead-man foot valve (off/on)
- Hydraulic valve bank for:
    - nozzle swing (left/right)
    - nozzle tilt (up/down)
    - center lifting device (up/down/off)
    - "jet" starter motor (on/off)
    - propulsion motors (fwd/reverse/off)
- Hydraulic booster valve (pump output) (low/high)
- Hydraulic diverter valve (motor config.) (series/parallel)
- "Jet" blower throttle (cont. low-to-high)
- Horn foot pedal (or button) (on/off)
- Windshield wiper knobs (one per wiper) (variable speed)
- Windshield washer buttons (front/rear) (on/off)
- Cab heater controls
    - heater fans (4 speeds) (on/off)
    - heater temperature (warm-cool, off)
    - heater fans (4 speeds) (off/1/2/3/4)
- Fuel heater (on/off)

The following lighting controls shall be provided in the cab and conveniently located for the operator:

- Electric power control switch (on/off)
- Headlights (front and rear) (2 sw) (on/off)
- Marker lights (1 sw) (on/off)
- Floodlights (individually controlled) (on/off)
- Beacon light (on/off)
- Cab dome light (off/on)
- Console light(s) (off/on)
- Map light (on/off)
- Headlights (high/low beam)
- Cab dome light (dim/bright)
- Console light(s) (dim/bright)

The following annunciators* shall be provided on the instrument console for the operator's information:

- Diesel oil pressure Low
- Diesel coolant temperature High
- "Jet" blower exhaust temperature High
- Beacon light On
- Headlights (front end) On
- Headlights (rear end) On
- Cab heater On
- Fuel heater On
- Center lifting device fully retracted
- Center lifting device fully lowered
- Center lifting device angle alignment (to rails)
- "Jet" blower fuel filter needs replacement
- Diesel fuel (for propulsion) Low
- Diesel fuel (for "Jet" blower) Low
- Headlight bright

*Indicator lights may be used for these annunciators.

8.0 RAIL-MOUNTED ROTARY BLOWER

The rail-mounted rotary blower snow removal vehicle may be specified in two alternative configurations:

- A cab and a rotary snow blower on one end (single-ended).
- A cab and a rotary snow blower on each end (double-ended).

In general, these specifications establish the requirements for the single-ended configuration. If a double-ended vehicle is specified, the cab and snow blower requirements for a single-ended vehicle shall also pertain to the second cab and snow blower of the double-ended vehicle unless referenced by the Purchaser.

8.1 Performance Requirements

The performance requirements or functional capabilities required for a rail-mounted rotary snow removal vehicle are described below.

8.1.1 Functional Capabilities

The functional capabilities required for a rail-mounted rotary blower snow removal vehicle are as follows:

- Self-propelled, in either direction of travel, with an on-board power source. Capable of traveling at speeds up to ____ mi/hr.

- Continuous operation while removing snow, without need for fuel or maintenance for at least 8 hr.

- Capable of being towed from either end, at speeds up to ____ mi/hr.

- Capable of traveling over the entire rail network of the Purchaser including all yards and shops.

- Capable of removing snow and ice, both in the rail yards and along the right-of-way. The nominal snow removal capacity shall be 1500 tons/hr. The snow removal profile shall be in conformance with the Purchaser's clearance template.

- Capable of towing a pair of revenue cars (with passengers) anywhere along the right-of-way.

- Capable of removing snow or towing cars in either direction of travel. *

- Capable of carrying a seated crew of four with all the necessary tools, and controlling all operations from the cab.

8.1.2 Operating Modes

The rotary snow blower shall have four operating modes, as follows:

- Travel Mode
- Snow Removal Mode
- Tow Mode
- Vehicle Towing Mode

Operations in each of these modes are described below.

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*Double-ended configuration only.

Travel Mode - The vehicle shall be capable of independent, self-propelled travel at forward speeds up to _____ mi/hr in this mode. Travel in reverse shall also be possible at speeds of up to _____ mi/hr.

Snow Removal Mode - The vehicle shall be capable of independent, self-propelled travel at forward speeds of up to _____ mi/hr in this mode. Travel in reverse shall also be possible.

Tow Mode - The vehicle shall be capable of being towed by another vehicle with towing means at either end of the vehicle.

Vehicle Towing Mode - The vehicle shall be capable of towing a pair of revenue cars of the Purchaser's car configuration, filled with passengers, as a necessary aspect of clearing the right-of-way. Adhesion, tractive effort, and braking capability shall be adequate for towing the pair of revenue cars with grades of up to five percent.

8.1.3 Snow Removal Capacity

The vehicle shall be capable of traveling or removing snow in either direction of travel. It shall be capable of removing snow of any consistency from the yards or right-of-way. Width of the cleared swath shall be as specified by the Purchaser. Average depth of snow shall be as high as two feet, with three foot drifts. The average rate of snow removal shall be at least 1500 tons/hr. The width and contour of the rotary blower shall be capable of providing a snow removal profile that complies with the Purchaser's clearance template.

The snow discharge chutes shall be movable, both side-to-side and up or down, by means of cab-operated controls. Means shall be provided

to select the azimuth angle (from the forward direction) and the throw range of the stream of discharged snow within the following limits:

- Discharge angle: ±135 degrees
- Discharge range: 15 ft to 100 ft

8.1.4 Propulsion and Braking

The vehicle shall be capable of accelerating at a rate of 0.75 mi/hr/sec on level, tangent track, when fully loaded with fuel and a crew of four, with rotary snow blowers Off.

When a rotary snow blower is On and plowing at full throttle, the vehicle shall be capable of traveling up to a five percent grade at a speed sufficient to achieve the rated snow removal capacity (Section 8.1.3).

Travel speed requirements for each mode of operation shall be specified by the Purchaser. When towing other vehicles up a five percent grade, the vehicle shall be capable of a travel speed of at least ____ mi/hr.

Pneumatic fail-safe brakes shall be applied on all driving wheels. Two braking rates shall be provided:

- Service brake rate of 2.5 mi/hr/sec.
- Emergency brake rate of 3.0 mi/hr/sec.

Braking action shall be equally effective in either direction of travel.

In the event of a braking component failure, at least half of the desired braking rate shall be achieved.

An independent parking brake shall act on at least one axle. It shall be capable of holding a fully-loaded vehicle parked on a five percent grade with two revenue cars (filled with passengers) in tow.

Means shall be provided for emergency release of the brakes, from within the cab, in the event that the brakes are applied due to an air system failure. This feature allows the vehicle to be towed after an air brake failure.

8.1.5 Coupled Operations

The rotary snow blower vehicle shall be capable of being towed from either end. When towed, the diesel engine shall be On, where possible, to provide auxiliary power for braking. The power drive shall be in Neutral and the rotary snow blower shall be Off.

Travel speeds for coupled operations shall not exceed _____ mi/hr or the posted speeds, if lower.

8.2 Design Features

Design features that shall be specified in order to purchase a rail-mounted rotary snow blower vehicle that would meet the performance requirements of Section 8.1 are described below. Alternative designs and optional features are also described below.

8.2.1 Frame

The chassis frame shall be constructed of welded steel channel, rigidly braced and reinforced. The chassis frame shall have adequate strength and rigidity for the intended loads and services. Material strength and section modulus for each frame member shall be selected to avoid permanent deformation or operational problems due to elastic deformations when loads expected under intended service are applied.

The vehicle frame shall be designed to accommodate the following features:

- Means for towing shall be provided at the snow blower end with a moveable coupler support (Section 8.2.6). The coupler unit for this support shall either be provided or specified by the Purchaser.

- Means for towing shall be provided at the end without a snow blower for attachement of a tow bar or a coupler as determined by the Purchaser. If required, the coupler unit or the tow bar shall either be provided or specified by the Purchaser. The towing bar shall be stored in the cab or in a location easily accessible to the crew.

- Jacking pads shall be provided at the end sills and those portions of the side sills that are clear of the swing of the truck assemblies.

8.2.2 Suspension

The vehicle chassis frame shall ride on two 2-axle trucks. Spacing between truck centers shall not exceed ____ ft, _____ in, and the axle spacing on each truck shall not exceed ____ ft, _____ in.

The snow blower shall be attached to the main body of the vehicle in such a manner that it can be easily and quickly detached from the main body with simple hand tools.

A suitable suspension system and shock absorbers shall be used. This suspension shall provide sufficient rigidity so that the vehicle body profile remains inside the dynamic outline under all conditions of load and use.

8.2.3 Wheels, Axles and Bearings

The vehicle wheels shall be solid cast steel 28 in. in diameter. The tread and flange profile shall be specified by the Purchaser. The AAR standard wheel gauge dimensions and tolerances shall be used, unless otherwise specified by the Purchaser.

Axles shall conform to AAR standards, using an alloy steel.

Tapered roller bearings for each wheel shall conform to AAR standards. Service life shall be based on maximum axle loads and rated for a bearing life (B-10) of 300,000 miles.

Wheels, axles and roller bearings shall be mounted using pressures and interference fits as specified in the AAR Wheel and Axle Manual.

Wheels, axles and bearings shall all operate without excessive vibration, wobble or eccentric action at all speeds up to 40 mi/hr or the maximum speed at which the vehicle shall be used, if higher.

8.2.4 Brakes and Pneumatic System

The braking system shall consist of the following major components:

- Air compressor
- Air reservoir tank
- Engineer's valve
- Brake actuators and tread brake shoes (8)
- Emergency stop valve (parking brake)
- Emergency hand pump (hydraulic)
- "Dead-man" foot valve

These components shall be connected with suitable air lines, check valves, etc., and properly adjusted to obtain the desired performance. An air horn shall also be supplied directly from the air reservoir tank and a tank pressure gauge shall be installed on the cab console.

Details for the major components are described below:

The air compressor shall be mechanically driven from the diesel engine. It shall be of an approved type, and equipped with a dessicant air dryer. The nominal discharge pressure shall be 130 lb/in^2 and the capacity shall be adequate to fully charge the air reservoir tank in an interval of ____ minutes on a cold start. The compressor shall

be equipped with safety valves and a regulating governor to maintain the pressure in the air reservoir within a prescribed range.

The air reservoir tank shall have a volume at least eight times the combined displacement volume of the eight brake actuators. It shall be of welded steel construction and designed for a nominal pressure of 150 lb/in^2. Wall thickness shall be based on a factor of safety of eight or greater. The tank shall be fitted with:

- An automatic drain cock equipped with an electric heating element thermostatically controlled placed at the the lowest point.
- A safety relief valve - set to 160 lb/in^2.

Design and pressure testing of this pneumatic tank shall conform to the ASME Boiler and Pressure Vessel Code.

The Engineer's valve shall be of an approved design and conveniently located on the console in the cab. It shall not be used for a parking brake. The following valve positions shall be provided:

- Emergency brake
- Service brake (minimum to maximum)
- Lap
- Release
- Handle Off

The Engineer's valve handle shall be capable of being removed from the valve stem in the Handle Off position. The Handle Off position shall be in a fail-safe portion of the valve quadrant.

Brake actuators. A total of eight truck-mounted pneumatic brake actuators shall be provided and shall be designed for long life with minimum maintenance. Each of these brake actuators shall control a single wheel tread brake shoe. Braking shall be equally effective in either direction of travel.

All eight brake actuators shall be of the fail-safe type and with automatic slack adjusters.

A supplementary snow brake shall be provided. When actuated by a switch on the cab console, it shall press each brake shoe against its wheel tread with a small, constant force, to prevent snow and ice build-up between wheel treads and brake shoes. A console annunciator shall indicate when the snow brake is On. The snow brake constant force shall be easily adjustable by maintenance personnel.

An emergency stop valve shall be provided and be so located so as to insure ease of accessibility, maintenance and resetting. This valve shall also serve as a parking brake.

This parking brake shall be capable of holding the vehicle when parked on a five percent grade, with two loaded revenue cars coupled to it.

An emergency hand pump shall be provided to unlock the fail-safe brakes, in the event that air pressure is lost for any reason. This hand pump shall apply hydraulic pressure to release the fail-safe brake actuators so that the vehicle may be towed in an emergency.

A "dead-man" emergency release foot valve shall be provided. Operation of this foot valve shall enable the emergency hand pump to be used to release the brakes in order that the vehicle may be towed in the event of a loss of air pressure in the braking system. When this foot valve is released, the hydraulic pressure provided by the hand pump shall be removed, reapplying the brakes.

8.2.5 Diesel Engine

A diesel engine shall provide the on-board power source for vehicle propulsion, the rotary snow blower, and all auxiliary equipment not battery-powered and the alternator. The diesel engine shall be rated or sized to provide adequate torque and horsepower for all needs, including the propulsion acceleration requirements (Section 8.1.4) and still possess a power margin of 25 percent.

A 2-stroke, fuel injected, water-cooled diesel engine suitable for rail service shall be provided. All standard equipment for this engine for rail application shall be included unless otherwise indicated, whether or not that equipment is specified herein.

The diesel engine shall be certified to operate on Nos. 1 and 2 fuel. As delivered, it shall be tuned for use with No. ____ fuel.

The engine shall provide sufficient power for propulsion and all equipment functions when used in the extreme environments described in Section 3.

The engine shall be mounted on the vehicle with isolation pads.

The engine shall be capable of starting within 10 seconds or two-thirds of the cranking system's time rating, whichever is shorter.

The engine shall be equipped with replaceable cartridge-type oil and fuel filters.

The engine cooling system shall be of sufficient capacity to permit continuous operation of the engine at full load, with ambient temperatures as high as 110° F.

An ethylene glycol permanent-type anti-freeze with rust inhibitors satisfactory for winter and summer services shall be added to the coolant in sufficient concentration to provide protection to - 40° F (-40° C).

The engine shall be equipped with a single-stage dry-type air cleaner. The cartridge shall be replaceable and have a condition indicator. The air cleaner shall have an automatic moisture and dust evacuator, and be designed so as to prevent freeze-up during winter snow clearing work.

The engine shall be equipped with a 120 Volt engine block heater to facilitate cold weather starting. The electrical connection for the engine block heater shall be conveniently located, of weather-proof design, and shall be of the male recessed type. At the discretion of the Purchaser, a direct hot water engine block heater may be provided in place of the 120 Volt engine block heater.

The engine exhaust system shall be equipped with a special low-noise muffler and any additional devices required to conform to provisions

of the Clean Air Act of 1970. The tail pipe shall be vertical, located at the top of the vehicle, and protected by a rain cap. The exhaust system shall accommodate the thermal expansion and vibration caused by normal use, and shall be located so that their heat shall not adversely affect nearby equipment; safety guards shall be used to protect personnel, if required.

The engine shall be equipped with a 12 Volt alternator and voltage regulator for charging the battery. Alternator current rating shall be _____Amperes.

The engine radiator and fan shall be enclosed in a well ventilated housing fabricated from 16 gauge sheet metal over an adequate support structure. Clearances inside the engine cabinet shall be adequate for all routine engine maintenance and replacement. Doors shall be large enough to permit easy access. They shall be hinged to open wide and shall not be less than 18 gauge steel. Non-skid type open grating shall be provided in the area near the engine enclosure.

The engine shall be started, stopped, and throttle-controlled from the cab. A suitable ignition key shall be required to operate the diesel engine.

Engine oil pressure and coolant temperature, engine speed and battery charging current shall all be shown on indicators conveniently located on the cab console. Means shall be provided for automatic engine shutdown, should the engine oil pressure be too low or the engine coolant temperature be too high. Annunciators shall be installed on the cab console to alert the operator when these shutdowns occur.

8.2.6 Rotary Snow Blower

A rotary snow blower shall be rail-mounted and attached to the front end of the vehicle. It shall consist of the following major components:

- Frame
- Wheels/Axles
- Rotary mechanism (2-stage)
- Discharge chutes
- Coupler arm
- Hydraulic actuators

Design features of these components are described below:

Frame - The welded steel frame shall support the rotary mechanism, discharge chutes, actuators, and coupler arm. It shall be flexibly attached to the front end of the main chassis of the vehicle by a suitable means.

Wheels/Axles - Either one or two pairs of steel flanged wheels shall support the rotary snow blower and guide it on the track. These wheels shall be free-running and mounted as far forward as possible (without interfering with operation of the rotary mechanism) to reduce snow blower overhang. The wheels shall be solid cast steel ____ inches in diameter. The tread and flange profile shall be specified by the Purchaser. The AAR Standard wheel gauge dimensions and tolerances shall be used, unless otherwise specified by the Purchaser. Axles shall be made of solid alloy steel with a minimum diameter of 4 inches.

Rotary Mechanism - The rotary mechanism or rotary head shall employ a 2-stage design, consisting of a helical cutter (or auger) for the first stage and a high-speed impeller for the second stage. The first stage shall cut and gather the snow and feed it laterally to the center

of the auger, where it enters the eye of the high-speed impeller. This lateral motion of the snow shall not be dependent upon the forward motion of the vehicle. Width of the helical cutter shall be specified by the Purchaser.

The drive for the rotary mechanism shall be either hydrostatically or mechanically powered. A hydrostatic drive shall use a diesel-driven hydrostatic pump (variably-vaned) to drive a hydrostatic motor (fixed vaned) to drive the rotary mechanism. Alternately, a mechanical drive shall use a diesel-driven gearbox, mechanical clutch, and other gearing to drive the rotary mechanism. The speed of the rotary mechanism shall be controllable from the cab, and shall be compatible with the speed range of the vehicle when it is removing snow. Maximum auger speed shall be ____rev/min and maximum impeller speed shall be ____rev/min.

The rotary cutter casing shall be curved to the contour of the helical cutter blade assembly to provide efficient snow flow and to prevent dozing action at the scraper blade and dribbling of snow around the ends of the head. Drain holes in the bottom of the rotary casing shall prevent ice buildup (from refreezing of melted snow) which could prevent the auger from turning.

Shear pin protection shall be provided for the auger to protect the drive mechanism from damage should foreign objects be ingested and become jammed in the mechanism. Shear pins shall be located so that they are easily and quickly replaceable using simple tools. Protection shall also be provided for the impeller should foreign objects be ingested and become jammed in the mechanism. This protection shall be in the form of shear pins or automatic resetting hydrostatic limiting devices as specified by the purchaser. Shear pins (if used) shall be so located so that they are easily and quickly replaceable using simple tools. Limiting devices (if used) shall be located in an area easily accessible for maintenance.

The entire rotary head (auger and impeller) shall be mounted with hydraulic actuators so that it can be raised or lowered by at least _____ inches. In its lowest position, the auger shall be within _____ inches of the rail.

Special care shall be taken that neither the frame nor the rotary mechanism can come into contact with the third rail. All materials possibly coming in contact with the third raill shall be nonconductive. All materials possibly coming in contact with trip arms or other wayside equipment shall be designed so as not to result in damage to the wayside equipment or the vehicle. The Contractor shall present evidence to show that no part of the snow removal equipment will present mechanical interference with any wayside equipment or structures, even on the sharpest curves of the Purchaser's rail network.

Discharge Chutes - The rotary head shall be equipped with two discharge chutes:

- A primary chute
- A spotcast chute

The primary chute shall be used to throw the discharged snow to either side of the vehicle for the maximum distance, or into the spotcast chute.

The spotcast chute shall be used to direct the discharged snow closer to the cleared right-of-way and to load snow trucks for disposal. This chute shall be provided with both range and azimuth controls.

Both discharge chutes shall be cab-controlled.

Coupler Support - A hydraulically-actuated coupler support shall be provided on the front end of the rotary snow blower to provide coupling to other vehicles. It shall be equipped with a coupler head of a type specified or provided by the Purchaser.

The moveable coupler support shall have two positions:

- Up - retracted when not in use.
- Down - extended for coupling.

The coupler support position shall be cab-controlled, and means shall be provided for latching the coupler in the Up and Down positions.

When removing snow, the coupler support shall be Up to prevent damage to the coupler from ingested snow. It shall not obstruct the operator's field of view to an undue degree.

An emergency backup hydraulic system with a manual hand pump shall be provided for moving the coupler support up or down at a reduced rate, should the hydraulic pressure be lost for any reason.

Hydraulic Actuators - shall be provided to control the following snow blower functions:

- Rotary head (up or down)
- Coupler Support (up or down)
- Primary chute (left or right)
- Spotcast chute (left or right, and short range or long range)

Controls for all hydraulic actuators shall be conveniently located in the cab.

The manual emergency backup hydraulic hand pump shall be capable of raising or lowering the rotary head and coupler support and moving the primary chute and spotcast chute left to right - all at reduced rates.

8.2.7 Cab

The vehicle shall be furnished with a fully enclosed, weather-tight operator's cab that contains all of the controls, switches and instruments necessary for the complete operation of the vehicle. The cab shall have sufficient seating capacity for three other crew members,

in addition to the operator. The cab structure and skin shall be of steel, and it shall have at least one entry door in the rear, accessible by a rear catwalk with appropriate hand rails. The cab door(s) shall have a suitable latch and lock.

The cab shall be mounted on the vehicle structure high enough for good visibility and insulation shall be added in the walls to reduce cab noise and meet cab heating requirements. The cab roof shall have beveled or rounded side edges to increase clearances in tunnels.

All cab windows except for the windshield shall be laminated safety sheet glass 3/16 in. thick. The cab windshield shall be laminated safety plate glass 1/4 in. thick. Windows shall be located on the front and side cab walls, and a fixed pane shall be used in the door(s). The side windows shall be of the two-section type, vertically split, with each section allowed to slide horizontally. Each side window shall be designed to provide an emergency exit for the crew. The side windows shall lock from the inside.

The windshield shall be equipped with suitable windshield wipers. Ice shields and/or rubber coated wiper blades shall be used to prevent blade ice-up in severe weather. Each wiper shall be pneumatically driven with a variable-speed control, conveniently located. Windshield washers shall be installed near each of the windshield wiper units for improved visibility. These washer units shall be fed from one fluid reservoir which shall be easily refilled and conveniently located (and supported) inside the cab, and controlled by buttons on the control console.

The windshield and the fixed pane(s) in the door(s) shall each be equipped with electric defogger units attached to their inside surfaces

and controlled with a switch (with integral indicator light) located on the operator's console.

The cab shall be equipped with a diesel-fueled heater of adequate capacity to maintain a cab temperature of at least 55° under the most severe weather conditions (Section 3.1). Heater design features described in Section 7.2.7 shall be applicable.

The cab shall be equipped with ventilators to ensure an adequate supply of fresh air. They shall be easily opened from inside the cab, as needed.

The cab shall be equipped with a pair of sun visors for the left and right sides of the windshield. They shall be as provided in Section 7.2.7.

The cab shall be equipped with a tool box with an approved hasp and lock.

The cab shall be equipped with a ceiling-mounted dome light, instrument panel back lighting, and a portable map light on a six-foot coiled extension cord, all controlled at the console. The dome light and the instrument lighting shall have integral full-range dimmer switches for improved night visibility.

The cab exterior shall be equipped with four headlights - two front and two rear. (See note below). They shall be of the halogen, 12 Volt automotive type, and mounted so that they can be aimed and adjustable from the outside and set to illuminate a person of average height standing on the tracks at a distance of 500 feet, and wearing dark clothing and shall be accessible from outside the vehicle for replacement. The controls for these lights shall be located on the cab control panel; they shall be operated in front and rear pairs using two switches. High/low beam switches shall be provided. These switches shall be either foot operated or by toggle located on the cab console. (Note - for a double-ended vehicle - the cab exterior shall be equipped with two front headlights and a single control switch for these lights shall be located on the cab console).

The cab exterior shall be equipped with marker lights. The number used, their size, color and their exact placement shall be specified by the Purchaser. Marker light fixtures shall be of impact-resistant plastic and shall be easily accessible from the outside of the vehicle for lamp replacement. Control shall be with a single switch on the cab console.

The cab exterior shall be equipped with a rotating, amber beacon light mounted on the cab roof and operated by a switch on the control panel.

The cab exterior shall be equipped with a pair of sealed beam floodlights suitable for outdoor use. Each floodlight shall be mounted on the outside of the cab wall just below the roof - one in the right front corner and the other in the left rear corner. Each floodlight shall be manually aimed from inside the cab, using a remote linkage handle with an integral on/off switch.

The cab exterior shall be equipped with a pneumatically operated dual horn mounted outside the cab and actuated by an operator's horn pedal or button in the cab. The dual horn shall be provided with snow covers that can be installed to prevent snow ingestion in the horn tubes.

The battery shall be a 12 Volt lead acid type with a ____ ampere-hour rating. The battery shall be located outside the cab in a well-ventilated and protected enclosure. Access to the battery for maintenance and replacement shall be convenient. Battery installation shall be approved by the Purchaser.

The cab shall be equipped with a heavy-duty battery cut-off switch. Electrical protection shall also be provided for each electrical circuit with a panel of resettable circuit breakers of approved design. These breakers shall be as provided in Section 7.2.7.

Both the operator's seat and the second forward seat shall be adjustable in height with an adjustable back angle and shall be as provided in Section 7.2.7. The third and fourth cab seats may be wall-mounted fold-up types, if desired, to prevent crowding in the cab. All cab seats shall meet the requirements as specified in Section 4.3.4.

The general cab layout, arrangements for cab seating, instrument consoles and controls, day/night visibility, and other human factors affected by cab design shall conform to requirements outlined in the Department of Defense document MIL STD 1472-13-C (Issued 2 May 1981), "Human Engineering Design Criteria for Military Systems, Equipment, and Facilities."

8.2.8 Fuel System

The vehicle shall be equipped with a welded steel fuel tank to supply the diesel engine. Tank capacity shall be adequate to supply the diesel fuel needs for 8 hours of continuous operation.

The fuel tank shall be located so as not to be in close proximity to the third rail, and shall be protected to prevent its damage from a low-speed vehicle impact.

The filler opening located at the top of the tank shall have a minimum internal diameter of 2 in. A removable strainer and a hinged filler cap suitable for switch locks or common padlocks shall be provided. The tank shall be vented in accordance with best current practices.

An oil-fired hot water heater with immersion coils located in the fuel tank shall be provided to facilitate cold-weather start-ups. The heater shall be of an approved design and installed in a well-protected, ventilated location outside the cab. Heater control shall be from the cab console.

A fuel transfer pump of approved design shall be provided to permit fueling the tank from fuel drums located at ground level. Pump capacity shall be adequate to transfer all the fuel in a ____ gallon drum in no more than ____ minutes.

8.2.9 Hydrostatic Propulsion Drive

The vehicle shall be equipped with hydrostatic propulsion drive to power all four truck-mounted axles from the diesel engine prime mover. Vehicle speed range shall be from 0 mi/hr to 30 mi/hr and adequate tractive effort shall be delivered to the wheels to meet all acceleration requirements of Section 8.1.4.

The rotary snow blower shall also be powered by hydrostatic drive, using a separate motor/pump system.

The following major components shall be used if hydrostatic propulsion drive is selected:

- Hydrostatic pump (2) (variable vaned).
- Hydrostatic motors (2) (fixed vaned).
- Diverter valve.
- Control lever (throttle).
- Brake actuator release cylinders (hydraulic).
- Hydrostatic/hydraulic reservoir.

These components shall be connected with suitable hydraulic lines, check valves, relief valves, testing tees, in conformance with the standards of the National Fluid Power Association (NFPA), American National Standards Institute (ANSI) and International Standards Organization (ISO).

Hose sizes for connecting these components shall be selected on the basis of fluid pressure in accordance with the following table:

Pressure PSI	Hose I. D. Size (Inches)
5500	1/4
4500	1/2
4000	3/4
3250	3/4
3000	3/4
2500	1
2250	1-1/4
1750	1-1/2
1250	2

Details of the major hydrostatic/hydraulic components are described below.

The hydrostatic drive shall consist of a diesel-driven hydrostatic pump (variable vaned) driving two hydrostatic motors (fixed-vaned). One motor shall be mounted on each of the two trucks, driving both axles on the truck by positive mechanical means.

Vehicle speed shall be controlled by changing the vane angles in the hydrostatic pump. A zero vane angle shall correspond to neutral, and maximum positive vane angle shall correspond to maximum forward speed; maximum negative vane angle shall correspond to maximum reverse speed. The vane angle shall be controlled by the operator seated in the cab, using a suitable throttle linkage.

A diverter valve or series/parallel valve shall be provided for the operator to alter the hydraulic system configuration of the pump and the two propulsion motors. When this valve is set in one position, these motors shall be connected in parallel and maximum torques developed. When this valve is set in the second position, these motors shall be connected in series, and smaller torques developed. The diverter valve handle shall be located inside the cab and conveniently located for the operator.

The hydrostatic pump, motors, valves, and flow lines shall be designed to operate at a pressure of at least 4000 lb/in^2. The pump and motors shall be sized to deliver the greatest tractive effort that shall be required to meet vehicle propulsion requirements (Section 8.1.4), and a power margin of 25 percent shall also be provided to reduce the possibility of pump "burn-out" under severe operating conditions.

A control lever (throttle) shall be provided for the continuous adjustment of drive speed in both forward and reverse directions. This throttle shall also have a neutral position. When the control lever is in the maximum Forward position, the hydrostatic propulsion drive shall be capable of delivering adequate horsepower to the wheels so that the specified maximum vehicle speed is achieved.

Brake actuator release cylinders shall be provided for emergency release of all of the brake actuators, in the event of a loss of air pressure. These cylinders shall operate to release the spring-applied brakes and permit emergency towing, should these brakes become locked up. A hydraulic hand pump and a dead-man emergency release foot valve shall both be operated in the cab for the emergency release of locked-up brakes, as described in Section 7.2.4.

A hydraulic reservoir or tank shall be provided of sufficient capacity to supply fluid to all the hydraulic equipment on the vehicle. It shall be of welded steel construction and provided with approved means for filling and venting. Magnetic drain plugs shall be provided at the bottom of the tank. Relief valves, check valves and intake and suction filters and a fluid level gauge shall be provided as necessary. A non-integral type of hydraulic reservoir is preferred, and the filler cap shall be designed to be locked with a large railroad padlock.

The design and pressure testing of the hydraulic tank shall conform to the ASME Boiler and Pressure Vessel Code.

A temperature sensor shall be mounted in the hydraulic reservoir to send hydraulic fluid temperature signals to an annunciator conveniently mounted on the console in the cab.

Additional hydraulic/hydrostatic equipment (if used) that must be considered when sizing the hydraulic reservoir tank are:

- Hydrostatic drive for rotary snow blower auger and impeller.
- Hydraulic drive for aiming snow blower discharge chutes.

- Hydraulic drive for raising/lowering snow blower head.
- Hydraulic drive for raising/lowering coupler support.
- Hydraulic drive for raising/lowering and powering. sweeper brooms (if used).
- Hydraulic drive for front-end broom (if used).

The hydraulic/hydrostatic system shall be provided with cooling means, if necessary, so that the fluid temperature shall not exceed 180° F, regardless of the ambient temperature or the operation performed. The minimum fluid temperature after 45 min. operation shall not be lower than 100° F.

The total return line and/or pressure line flow shall pass through filters rated at 25 microns or finer, equipped with a condition indicator. Filtration details, as recommended by the pump manufacturer, shall apply. Magnetic particle attraction shall be provided either in the filters or the reservoir to trap unwanted metal particles.

8.2.10 Electric Propulsion Drive (If Used)

Electric propulsion drive shall be considered as an alternative to hydrostatic drive. If it is used, then the design features listed below shall apply.

Electric propulsion shall operate over a speed range of 0 mi/hr to 30 mi/hr and adequate tractive effort shall be delivered to meet all acceleration requirements in Section 8.1.4. The following major components shall be used for this drive.

- Alternator or dc generator
- Traction motors (4)
- Multi-step dc controller, reverser (if used).

These components shall be selected and installed as described below.

Alternator or generator - An alternator or dc generator shall be provided as specified by the Purchaser. The alternator or generator shall be direct-driven from the diesel engine and the kW rating shall be adequate to transmit the continuous maximum output of the diesel engine under all conditions for which the vehicle is designed.

The alternator (if used) shall be provided with an integral solid-state rectifier to convert the ac output to dc. Rectified voltage shall be matched to the traction motor rated voltage (in the range of 300 Volts dc to 600 Volts dc). The alternator shall be blower-ventilated and the rotor driven directly by the diesel crankshaft by means of a flexible coupling. An auxiliary alternator shall be built integral with the main alternator to provide main generator excitation. It shall provide a rectified 200 V output to the main rotor, as well as a non-rectified ac output to drive the diesel cooling fans, (if desired).

The dc generator (if used) shall provide the desired dc voltage over the entire speed range of the vehicle. The dc generator shall be blower-ventilated and the armature directly driven by the diesel crankshaft by means of a flexible coupling.

Traction Motors - Four identical dc traction motors shall be provided, one per axle, for each of the 2-axle trucks. Each traction motor shall

be supported by the driving axle to which it is geared, and by additional resilient suspensions on the truck transom.

The voltage rating of the traction motors shall be selected by the Contractor and shall be in the range of 300 V dc to 600 V dc. The combined horsepower rating of the four traction motors shall be compatible with the kW rating of the alternator or dc generator.

The dc traction motors shall not be grounded to the vehicle body. They shall be wired to the ground of the rectified alternator output or the dc generator output.

The dc traction motors shall be series-wound, and shall be forced-ventilated.

Each traction motor shall drive its axle by means of a suitable gear unit. Gear ratios shall be selected for adequate tractive effort at the rail to accelerate and decelerate the vehicle in accordance with performance requirements of Section 8.1.4.

Traction motors shall be equipped with quick-access hinged inspection covers on top of motor only. Bottom inspection covers shall be the bolt-on type.

Means shall be provided to lock out one or more traction motors from the cab. Horsepower shall be automatically reduced so that remaining motors are not overloaded when a motor is locked out.

Multi-Step DC Controller (if Used) - Propulsion control shall be provided by means of a multi-step controller (cam controller), operated from within the cab.

The reverser, contractors and cam switches of this controller shall be either electro-magnetically or electro-pneumatically operated. Circuit breaker type switches shall be utilized in low voltage control circuits where overload protection is required. High voltage propulsion circuits shall have ground fault as well as overload protection devices. These devices shall reset automatically within twenty seconds of each occurrence, up to a total of three, regardless of time interval between occurrences. The devices shall lock out on the fourth overload trip. When this occurs, power shall be removed, the alarm bell sounded, and a visual indication is given to the operator. The unit must then be reset manually.

8.2.11 Mechanical Propulsion Drive (If Used)

Mechanical propulsion drive shall be considered as an alternative to hydrostatic drive. If it is used, then the design features listed below shall apply.

The mechanical propulsion drive shall operate over a speed range of 0 mi/hr to 30 mi/hr and transmit adequate traction power from the diesel engine to all four truck-mounted axles by means of the following major components:

- A torque converter.
- A two-speed transmission.
- A mechanical drive train.

Torque Converter - A fluid coupling or torque converter with 2-phase, single-stage operation with lock-up capability shall be provided. The converter shall be driven by the diesel engine, and shall couple directly to the two-speed transmission.

Two-Speed Transmission - A two-speed automatic transmission shall be provided. This transmission shall provide both low and high speed ranges in both the forward and reverse directions.

Mechanical Drive Train - A positive mechanical drive train or final drive assembly shall transmit the tractive power from the transmission output to each of the four truck-mounted axles by means of four cardan shafts and four gear units, as follows:

- Cardan shafts (2), with universal joints at each end, shall transmit traction power from the transmission to gear units (2) mounted on the in-board axle of each truck.

- Each gear unit shall be double reduction and shall contain spiral bevel gears, to drive both the inboard axle it is mounted on and the outboard axle on the same truck, by means of a second or inter-axle cardan shaft.

- Each inter-axle cardan shaft shall also have universal joints on each end and shall transmit traction power to a single-reduction gear unit mounted on that truck's outboard axle.

Each cardan drive shaft shall have a sealed sliding spline section to compensate for variations in length during thermal expansion, truck rotation on curved track and assembly/disassembly procedures.

The gear ratios and shaft sizes shall be selected to transmit the maximum propulsion power and provide adequate tractive effort at the rail to accelerate and decelerate the vehicle in accordance with performance requirements of Section 8.1.4.

8.2.12 Cab Equipment and Controls

All design features and specifications for the cab equipment and controls for the single-ended rotary snow blower vehicle shall also apply for each cab of the double-ended rotary snow blower vehicle (see Section 8.0). The following shall also apply for the double-ended configuration:

- Propulsion and braking controls shall be identical in each cab, and the vehicle shall be able to be driven in either direction from each cab. Propulsion and braking interlocks shall be provided between the two cabs so that when propulsion and braking are operated from one cab, the propulsion and braking controls in the other cab are disabled, and cannot be used to operate the vehicle.

- Rotary snow blower controls shall be identical in each cab and used to operate the rotary snow blower nearest to that cab. Control interlocks for the rotary snow blowers shall be provided so that when one rotary snow blower is turned On the other rotary snow blower remains Off and cannot be operated.

- The following controls shall not be interlocked between the two cabs, but may be operated from either cab:
  - Lights (all interior and all exterior)
  - Horns
  - Sanders
  - Train control equipment (if used).

The cab shall be equipped with all the necessary instruments, gauges, annunciators and controls so that a single operator can operate the vehicle and operate the rotary snow blower and any optional equipment that is provided. Cab general layout of seating, controls, consoles, etc., shall be for convenient use in accordance with good human factors practices. The Department of Defense document MIL-STD-1472-C (issued 2 May 1981), "Human Engineering Criteria for Military Systems, Equipment and Facilities", shall be used as a guide. The following gauges shall be provided in the cab:

- Speedometer	mi/hr
- Odometer (with trip meter)	mi
- Clock	hr, min
- Air pressure (brake pressure)	lb/in^2
- Diesel fuel level	gal
- Diesel engine tachometer	rev/min
- Diesel engine oil pressure	lb/in^2
- Diesel engine coolant temperature	°F
- Diesel engine hour meter	hr, min
- Battery ammeter (or voltmeter)	Amps/Volts
- Hydraulic fluid temperature	°F
- " pump discharge pressure	lb/in^2
- " " inlet "	lb/in^2

The following devices shall be provided in the cab for the operator's control of the vehicle and all vehicle and optional equipment (if used):

- Diesel engine throttle (speed control)	(idle, low-to-high)
- " " shutdown button (fuel shut off)	(on/off)
- " " emergency shutdown button (air shut off)	(on/off)
- " " keyed ignition/start switch	(on/off/start)
- " " cold start button (if used)	(on/off)
- Engineer's valve (air brake valve)	(Emerg/Serv/Lap/ Release) (handle off)
- Emergency stop valve/hand brake	(on/off)
- Snow brake	(on/off)
- Emergency hand pump (hydraulic)	(manual)
- Dead-man foot valve	(off/on)
- Snow blower throttle (speed control)	(cont. low-to-high)
- Snow blower head position	(up/down)
- Primary chute	(left/right/up)
- Spotcast chute azimuth	(left/right)
- Spotcast chute range	(cont. min-to-max. range)
- Coupler arm	(up/down)
- Propulsion direction switch (or lever)	(fwd/reverse/neutral)
- Hydraulic diverter valve (motor config.)	(series/parallel)
- Horn foot pedal (or button)	(on/off)
- Windshield wiper knobs (one per wiper)	(variable speed)
- Windshield washer buttons	(on/off)
- Cab heater controls	
- heater	(on/off)
- temperature control	(° F)
- heater fan (2 speeds)	(low/high)
- Sander push button	(on/off)
- Fuel heater	(on/off)
- Deicer ② (if used)	(on/off)

The following lighting controls shall be provided in the cab and conveniently located for the operator.

- Electrical power control switch (on/off)
- Headlights (on/ off
- Marker lights (1 sw) (on/off)
- Floodlights (individually controlled) (on/off)
- Beacon light (on/off)
- Cab dome light (off/on)
- Console light(s) (off/on)
- Map light (on/off)
- Head lights (high/low beam)
- Cab dome light (dim/bright)
- Console light (dim/bright)

The following annunciators* shall be provided on the instrument console for the operator's information:

- Diesel oil pressure Low
- Diesel coolant temperature High
- Beacon light On
- Headlights (front end) ON
- Headlights (rear end) ON
- Cab heater On
- Fuel heater On
- Snow blower in operation
- Snow brake On
- Diesel fuel Low
- Deicer On (one for each side)

*Indicator lights may be used.

8.2.13 Sanders

Two sanders shall be provided. They shall be operated together to deposit sand on the rails in front of the leading wheels of the forward truck.

Each sander shall consist of a sandbox, a nozzle, and a flow actuator. Each sandbox shall be located to permit easy filling from outside the vehicle, with fill openings at least 3 inches in diameter. Fill covers shall be hinged and gasket seals used to keep out water. Capacity of each sandbox shall be at least two cubic feet.

Sander nozzles shall be located as close as possible to the rails and the lead wheels, and shall be designed to reject water caused by wheel splash.

Sanders shall be operated from the cab either by air pressure or by electrical means. A single flow rate shall be provided, which shall be easily adjustable by maintenance personnel.

It is noted that for the double-ended configuration (if used) there shall be no interlock or interconnection between the sander controls in the two cabs (Section 8.2.12). However, the sander controls shall be interlocked with the braking controls so that the sanders are automatically applied whenever the operator places the Engineer's valve in the Emergency Braking position.

8.2.14 Communications, Signalling and Train Control Equipment (If Used)

If the Purchaser elects to equip the vehicle with any of the communications, signaling, or train control equipment similar to that used in the fleet of revenue cars, then the following shall apply:

The equipment shall be similar to the equipment used on the revenue cars.

The plan for installation of this equipment shall be provided by the Contractor and approved by the Purchaser. The Contractor shall then install this equipment in accordance with the plan.

If the installation of this equipment is planned at some future date, then space shall be provided in the cab for this future installation when the cab layout is planned by the Contractor.

8.2.15 Optional Equipment

The following types of optional equipment shall be available to augment the snow fighting capabilities of the rail-mounted rotary snow blower vehicle:

- Front-end plows - to clear right-of-way.
- Front-end brooms - to clear right-of-way.
- Truck-mounted brushes - to clear the third rail.
- Truck-mounted ice scrapers - to clear the third rail.
- Truck-mounted deicers - to clear the third rail.
- Roof-mounted ice scrapers - to clear the overhead catenary wire.

If any of the above types of optional equipment are selected by the Purchaser for the vehicle, then the paragraphs below that pertain to the selected optional equipment shall apply.

Front-End Plows - A front-end mounted plow may be used as an alternative means of clearing the right-of-way. Two types of front-end plows are available:

- V-shaped plow.
- Straight-bladed plow.

Generally, the smaller angle-of-attack of the V-shaped plow allows it to push through deeper drifts and with less tractive effort, than the straight-bladed plow. However, a moveable straight-bladed plow can be operated to deposit all of the snow to one side (the side without the third rail) which is a desirable performance feature when removing snow from a transit system right-of-way.

The following features shall apply to either type of front-end plow:

- The front-end plow shall be made of steel and its design shall be suitable for its intended use. Materials and workmanship shall conform to applicable portions of Section 4.
- A quick-disconnect type of mount shall be used to attach the plow to the front end of the vehicle.

- The operation of the plow shall be fully controlled from inside the cab, and hydraulic actuators shall be used to:
  - Raise and lower plow.
  - Rotate plow to either left or right (straight-bladed type only).

  The plow shall be raised and lowered with a total vertical stroke of ____ inches. At its lowest position, its bottom edge shall be____ inches above the top of the rail. This rail clearance shall be easily adjustable by maintenance personnel. The straight-bladed plow (if used) shall be capable of being rotated by____ degrees to either side, under cab control.

- Overall width of the front-end plow shall be _____ ft.

Front-End Brooms - A front-end mounted rotary broom may be used as an alternative means of clearing the right-of-way. While a rotary broom is generally not as effective as a rotary snow blower for deep, hard-packed, refrozen or wet, heavy snow, it is frequently quite adequate for clearing the right-of-way after the less severe storms. One advantage of a broom over a rotary snow blower is that it can be used to clear between the rails, and often down to the tops of the roadbed ties.

The following features shall apply to a rotary broom mounted on the vehicle front end:

- The rotary broom shall have a cylindrical shape with its spin axis horizontal and nominally normal to the

forward-pointing axis. It shall be made of steel and have non-conducting*, long-wearing bristles of suitable length and stiffness for the intended purpose. Materials and workmanship shall conform to applicable portions of Section 4.

- A quick-disconnect type of mount shall be used to attach the rotary broom to the front-end of the vehicle.

- The rotary broom shall be fully controlled from inside the cab, and hydraulically powered. These controls shall:
  - Raise and lower the broom.
  - Rotate the broom to either left or right.
  - Adjust the rotating speed of the broom.

The broom shall be raised and lowered with a total vertical stroke of _____ inches. At its lowest position, its bristle tips shall be nominally _____ inches above (or below) the top of the rail. The vertical rail clearance shall be easily adjustable by maintenance personnel, if desired, so that the broom can be lowered further until its bristles touch the tops of the ties, if desired.

The broom shall be capable of being rotated by _____ degrees to either side, under cab control. This shall allow the operator to minimize the amount of snow moved onto the third rail, by depositing it on the opposite side of the right-of-way.

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*Broom bristles shall provide insulation sufficient to withstand 3000 V dc per inch of bristle length, in accordance with IEEE Std. 11-1980.

The rotational speed of the broom shall be continuously adjustable with a throttle control located inside the cab. The maximum broom rotational speed shall be based on the maximum vehicle forward speed.

Overall width of the rotary broom shall be ____ ft, ____ in.

The overall diameter of the rotary broom shall be ____ ft, ____ in.

Truck-Mounted Brushes - Rotary brushes for removing snow from the third rail may be installed on the vehicle. If used, these brushes shall be mounted on the left and right corner of each truck frame that are nearest to the inboard truck axles, for a total of four identical brushes per vehicle.

These brushes shall be retracted (upward or inward) to a stored position when not in use (Off), and extended (downward or outward) to be in contact with the third rail when in use (On). The direction that these rotary brushes are extended shall depend on whether or not third rail covers are used on the Purchaser's rail network.

These brushes shall be hydraulically powered for:

- Extension (On) and retraction (Off).
- Brush rotation.

Each brush shall be operated at a fixed speed of ____ rev/min.

Each brush shall push against the top of the third rail with a vertical force of ____ lb.

Both brushes on the forward truck shall be operated when the vehicle is traveling in the forward direction, and both brushes in the rear truck shall be operated when traveling in the reverse direction. The direction of rotation of each brush shall be selected to provide the most effective cleaning of the third rail for the direction of travel when used.

The brushes shall be operated in front and rear pairs under cab control. When a pair of brushes is turned On, an annunciator on the cab console for that brush pair shall remain on until the brush pair is turned Off (and automatically retracted).

Each of the brushes shall use non-conductive bristles to sweep the third rail. Each brush shall also be electrically insulated from the vehicle body to withstand a voltage of 3000 V dc in accordance with IEEE Std. 11-1980*. The dc high potential test procedures described in this standard shall be used to verify that the brushes are adequately insulated.

Truck-Mounted Ice Scrapers - Steel scraper blades for removing ice from the third rail may be installed on the vehicle. If used, these ice scrapers shall be mounted into the left and right side frame members on each truck, for a total of four identical ice scrapers per vehicle.

Each ice scraper assembly shall be electrically insulated from the truck frame and the vehicle body. Insulation and electrical testing requirements for the third rail snow brushes shall also apply to the ice scrapers (IEEE Std. 11-1980*).

*IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles.

These ice scrapers shall be either manually or remotely actuated. Remote actuation (if used) shall be by pneumatic or electromechanical means. Provision shall be made for adjusting the vertical scraping force.

These ice scrapers shall normally be in the Up or retracted position, with blade tips clearing the third rail by at least ____ in. The vertical contact force of each ice scraper on the third rail shall be between _____lb and _____lb when the blade is in the Down position.

Truck-Mounted Deicers - Steel, perforated heads for dispensing deicer solution onto the third rail may be installed on the vehicle. If used, these deicer solution dispenser heads shall be mounted onto the left and right side frame members of the leading truck, for a total of two identical deicer dispenser units per vehicle.*

Each of these deicer heads shall be retracted upward or inward to a stored position when not in use or extended downward or outward when in use.

A tank of deicer solution with a capacity of _____gallons shall be provided to supply the deicer heads, using a gravity-flow feed. Separate flow valves shall be provided in the neoprene tubing from the tank to each deicer head, to shut off the flow of deicer solution, as desired.

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*For the double ended vehicle configuration (if used) the deicer solution shall be dispensed from each truck, rather than from one truck.

Each deicer head shall be lowered or retracted (and the corresponding flow valve opened or closed) by means of cab controls. One On/Off switch (and annunciator) shall be installed on the cab console for controlling the deicers on each side of the vehicle (for a total of two deicer switches per vehicle).

Each truck-mounted deicer head shall be electrically insulated from the truck frame and the vehicle body. Insulation and electrical testing requirements specified for the third rail snow brushes and ice scrapers shall also apply to the deicer heads (IEEE Std. 11-1980). *

Roof-Mounted Ice Scrapers - Steel scraper blades for removing ice from the overhead catenary contact wire may be installed on the vehicle.

The means used for supporting the roof-mounted ice scraper shall be a pantograph or trolley pole that is normally used for the Purchaser's revenue cars. It shall be either provided or specified by the Purchaser.

If a trolley pole is used, then means shall be provided to hold down the trolley pole when not in use.

If a pantograph is used, then it shall be operated remotely from the cab with the same control actuator and indicating light as used to operate this device on the revenue cars.

When this device is in use, it shall have a near-constant vertical force of ____ lb over an excursion of ___ ft to ____ ft above the roof line of the vehicle.

*IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles.

When this device is in the retracted or stored position, the top of the vehicle profile shall not lie outside the clearance envelope specified by the Purchaser.

Each ice scraper unit shall be electrically insulated from the vehicle body. Insulation and electrical testing requirements for the roof-mounted ice scrapers shall be similar to those requirements for the third rail ice scrapers (IEEE Std. 11-1980).

9.0 RAIL/HIGHWAY ROTARY BLOWER

9.1 Performance Requirements

The performance requirements or functional capabilities required for a rail/highway rotary blower snow removal vehicle are as follows:

9.1.1 Functional Capabilities

- Self-propelled, in either direction of travel with an on-board power source.
- Dual mode operation. Capable of traveling over highway or rail, and entering or leaving rail at any point. Highway travel at speeds up to ____ mi/hr and rail travel at speeds up to _____ mi/hr.
- Continuous operation while removing snow, without need for fuel or maintenance, for at least 8 h.
- Capable of being towed from either end, at speeds up to _____ mi/hr.
- Capable of traveling over the entire rail network of the Purchaser, including yards and shops.
- Capable of removing snow and ice from roads and rails. Snow removal rate shall depend on depth and consistency of snow/ice, but shall not be less than 1500 tons/hr. The snow removal profile shall be in conformance with the Purchaser's clearance template.

- Capable of locking/unlocking the differential on each axle under cab control to prevent loss of traction when a single wheel slips.

- Capable of reversing direction of rail forward travel, without need of a "wye" or turn-around loop, by means of a center-lifting device.

- Capable of carrying a seated crew of two in the cab, with all necessary tools, and controlling all operations from the cab.

- Four wheel drive, changeable to two-wheel drive, under cab control.

- Capable of operating various attachments by means of hydraulic couplings and power take offs at both ends of the vehicle.

9.1.2 Operating Modes

The rail/highway vehicle shall have six operating modes as follows:

- Rail Travel Mode
- Highway Travel Mode
- Rail Snow-Removal Mode
- Highway Snow-Removal Mode
- Rail Turning Mode
- Rail Tow Mode

Rail Travel Mode - The vehicle shall be capable of independent self-propelled rail travel at forward speeds up to ____ mi/hr in this mode. Rail travel in the reverse direction shall also be possible at speeds up to ____ mi/hr.

Highway Travel Mode - The vehicle shall be capable of independent, self-propelled highway travel at forward speeds up to ____ mi/hr in this mode. Highway travel in the reverse direction shall also be possible at speeds up to ____ mi/hr.

Rail Snow Removal Mode - The vehicle shall be capable of independent, self-propelled rail travel at forward speeds up to ____ mi/hr in this mode. Rail travel in the reverse direction shall also be possible. The rotary snow blower shall be used to remove snow/ice from the rail yards and right-of-way.

Highway Snow Removal Mode - The vehicle shall be capable of independent, self-propelled highway travel at forward speeds up to ____ mi/hr in this mode. Highway travel in the reverse direction shall also be possible. The rotary snow blower shall be used to remove snow/ice from the roads and paved lots.

Rail Turning Mode - The parked vehicle shall be raised above the rails with a center lifting device, rotated a half-turn (manually), then lowered onto the rails in this mode. This means of reversing the direction of forward travel shall be operative only when:

- the vehicle is uncoupled
- the propulsion drive is in Neutral
- the brakes are applied
- the rotary blower is Off

Interlocks shall prevent use of the center lifting device unless the last three conditions are met.

The center lifting device shall raise the vehicle sufficiently so that when rotated, it swings out above the third rail with a vertical clearance of at least three inches. A latch-up device shall lock the center lifting device while it is in the fully raised or lowered positions.

Rail Tow Mode - In the rail travel mode, the vehicle shall be capable of being towed by another rail vehicle, using the towing means at either end of the vehicle. The diesel engine, as described in Section 9.2.5 shall be On, where possible, to provide auxiliary power for the pneumatic brakes, and the rotary snow blower shall be Off. The center lifting device shall remain retracted while in this Tow Mode.

9.1.3 Snow Removal Capacity

The rail/highway vehicle shall be capable of removing snow of any consistency from paved surfaces and rail right-of-way. Width of the cleared swath shall be specified by the Purchaser. Average depth of snow shall be as high as two feet, with three foot drifts. The rate of snow removal shall be at least 1500 tons/hr.

9.1.4 Propulsion and Braking

The rail/highway vehicle shall be capable of accelerating from 0 mi/hr to 35 mi/hr at an average rate of 2.0 mi/hr/sec on either highway or level, tangent track, when fully loaded with fuel and a crew of two, and with the rotary snow blower Off.

When the rotary snow blower is On and operating at full throttle, the vehicle shall be capable of traveling up a five percent grade with a minimum speed of _____mi/hr.

Pneumatic/hydraulic direct-acting disc brakes shall be used for all four wheels. Braking action shall be equally effective in either direction of travel.

Brakes shall be operational in all modes except the Turning Mode, where the brakes shall be locked while the vehicle is lifted and rotated. In the event of a braking component failure, at least half of the desired braking rate shall be achieved.

An independent parking brake shall be provided. It shall be capable of holding a fully loaded vehicle parked on a five-percent grade.

Means shall be provided for emergency release of the brakes, from within the cab, in the event that the brakes "lock up" due to a pneumatic system failure. This feature allows a vehicle to be towed after a pneumatic brake failure.

9.1.5 Coupled Operations

The rail/highway vehicle shall be capable of being towed from either end. When towed, the engine shall be On to provide auxiliary power for braking, if possible, and the power drive shall be in Neutral. The rotary snow blower shall be Off and the center lifting device in the retracted position.

Travel speeds for coupled operations shall not exceed ____ mi/hr or posted speeds, if lower.

9.2 Design Features

Design features to be specified in order to purchase a rail/highway rotary blower vehicle that would meet the performance requirements of Section 9.1 are described below. It should be noted that since this vehicle is designed to operate on highways as well as on rail, all State and Federal codes and regulations pertaining to the design, construction, and operation of motor vehicles on public highways shall be complied with.

9.2.1 Frame

The chassis frame shall have a general highway truck body configuration and be constructed of welded steel channel, rigidly braced and reinforced. The chassis frame shall have adequate strength and rigidity for the intended loads and services. Material strength and section modulus for each frame member shall be selected to avoid permanent deformation or operational problems due to elastic deformations when loads expected under intended service are applied.

The vehicle frame shall be provided with the following features:

- A rear equipment deck shall be provided behind the cab for mounting an auxiliary engine or other accessories, as required.

- Means for towing shall be provided at each end of the frame for attachment of a tow bar. Details of the

towing means shall be provided by the Purhcaser. The towing bar shall be stored in the back of the vehicle and kept in place by two spring-loaded brackets, when not in use.

- Four jacking points shall be provided so that each of the four wheels can be raised for wheel-changing, if required.

- A roll bar shall be mounted to the frame for protection of the cab occupants. Installation shall be in accordance with the OSHA General Industry Safety and Health Standards.

- An audible intermittent-type backup alarm shall be provided and installed on the rear undercarriage of the frame. This alarm shall be sounded whenever the transmission is shifted into a reverse gear.

9.2.2 Suspension and Steering

The dual-mode vehicle shall be equipped with both a primary suspension and a secondary suspension. When travelling in either of the two highway modes, the vehicle shall be entirely supported by means of the primary suspension. When travelling in any of the three rail travel modes, the vehicle shall be 75 percent supported by means of the primary suspension and 25 percent supported by means of the secondary suspension.

Features of the primary and secondary suspensions, as well as the means used to steer the vehicle when operating in either highway mode, are described below.

The primary suspension shall consist of the four rubber tired wheels and suitable springs and hydraulic shock absorbers for improved control and handling on rough surfaces. The suspension used for the two front wheels shall also consider that these wheels must be steerable, when operating in either of the highway modes. The primary suspension shall provide sufficient rigidity so that the vehicle body profile remains inside the dynamic outline for rail use under all conditions of rail load and use.

The secondary suspension shall guide the vehicle so it remains on the rails for all rail-mounted travel modes of operation. When operating in either of the two highway modes, the secondary suspension shall be retracted upwards, and shall not interfere with either the primary suspension or any of the optional equipment that may be used in the highway modes of operation.

The secondary suspension shall employ four pairs of steel flanged wheels that shall make contact with the running rails when they are fully lowered. Two of these pairs of steel wheels shall be located forward of the rubber-tired front wheels, and the other two pairs shall be located rearward of the rubber-tired rear wheels. Each of the four pairs of steel wheels shall be bearing-mounted on and supported by a suitable housing. The housings that support the two forward pairs of steel wheels shall be flexibly connected to each end of a rigid transverse rod. These flexible connections shall permit each housing to rotate freely about the vertical axis as the two flanged steel wheels on the housing ride on the rail. A similar arrangement shall be used for the rear secondary suspension assembly. This arrangement shall be used in place of four conventional axle-mounted steel wheels to provide improved tracking performance on curved track. The Contractor shall demonstrate that the

vehicle can travel over rail with a radius of curvature as small as ____ ft without derailment. Travel speeds shall be limited to ____ mi/hr over unbroken track and to ____ mi/hr over crossovers, switches and other trackwork.

The front and rear transverse members of the secondary suspension shall each be connected to the vehicle frame by suitable linkage arms with integral hydraulic shock absorbers and air actuators. The actuator air pressure shall be adjustable so that the vertical force by which each set of steel wheels presses down on the rails is nominally set to ____ lb. Controls to vary these tracking forces (by means of air pressure), as well as an air pressure gauge to indicate the tracking forces, shall be provided in the cab.

Additional hydraulically actuated members shall rotate the entire forward assembly (and rear assembly) about their mounting points to the chassis frame, to lower or raise (retract) all rail-riding steel wheels, using a single cab control. When raised, the steel wheels shall clear the pavement by at least ____ in. so as not to interfere with highway mode operations. The raised steel wheels shall also not interfere with other undercarriage equipment, and a mechanical means shall be provided to latch up the retracted secondary suspension to prevent it from being lowered inadvertently.

All members of the secondary suspension shall be designed for their intended loads and use. They shall be built for heavy-duty service.

Steering of the vehicle shall be provided using conventional steering means that are typical for a heavy-duty highway truck. A cab-steering wheel shall be coupled to a conventional steering linkage to rotate both

front rubber-tired wheels. A hydraulic pump and motor shall provide a power-assist to this steering system to reduce the steering effort required by the operator. Diameter of the swept-out vehicle turning circle shall not exceed ____ ft.

The vehicle steering described above shall be used when the vehicle is operated in either of the two highway modes (Section 9.1.2). When the vehicle is operated in any of the rail modes, the vehicle steering shall remain locked so that the front wheels are set in a straight-ahead position.

9.2.3 Wheels, Axles and Bearings

The primary suspension shall be provided with a set of four rubber-tired wheels mounted on steel rims, which are bolted to the axle-mounting plates in a conventional manner for an automotive truck. The rubber tires shall use a closed rib tread for superior traction on rail. A tire size 10.5 x 20/10 PR shall be used. The tires shall be selected for heavy-duty service. Wheel bearings and axles for the primary suspension shall conform to automotive design practice for heavy-duty trucks.

The secondary suspension shall be provided with eight flanged steel wheels for contact with the running rails. These wheels shall be made of a suitable alloy steel and used in pairs. Each of the four pairs of wheels shall be mounted in a steel housing, using suitable bearings, with a bearing life (B-10) of 300,000 miles.

Wheel diameter shall be 5.6 in and wheel flange diameter shall be 8.1 in. The wheel profile and taper shall be specified by the Purchaser.

9.2.4 Brakes and Pneumatic System

The vehicle brake system shall comply with all applicable U.S. Department of Transportation Motor Vehicle Safety Standards.

Direct acting pneumatic/hydraulic brakes shall be provided for all four rubber tired wheels. A disc and caliphers shall be provided at each of these wheels. The caliphers shall be hydraulically actuated with a pneumatic-assist. The hydraulic reservoirs, lines and actuators for the front and rear brakes shall be independent, so that a hydraulic leak shall not result in a complete loss of brakes.

A parking brake shall be provided on at least two wheels. It shall be operated from the cab and capable of holding the vehicle when parked on a five percent grade.

An emergency release kit shall be provided.

One or more air reservoirs shall be provided, with a combined volume of at least eight times the total brake actuator displacement volume. The air reservoir(s) shall be designed and tested in accordance with the ASME Boiler and Pressure Vessel Code.

A suitable air dryer with an automatic heated moisture ejector shall be provided to remove moisture from the pneumatic system.

9.2.5 Diesel Engines

Two diesel engines shall be provided. The first diesel engine shall supply the power for:

- Vehicle propulsion (both highway and rail modes).
- All auxiliary and optional equipment, except for the rotary snow blower drive.

The second diesel engine shall power the rotary snow blower drive as a dedicated power source.

The first diesel engine shall be permanently installed under the hood of the truck chassis. The second diesel engine shall be installed on the rear deck of the vehicle, behind the cab, and shall be removable to provide increased off-season versatility for this vehicle.

The first diesel engine shall be rated or sized to provide adequate torque and horsepower for all needs as stated above (including the propulsion acceleration requirements in Section 9.1.4) and still possess a power margin of 25 percent.

The second diesel engine shall be provided with a supercharger to boost its rated horsepower in order to provide a snow removal capacity of 1500 tons/hour.

9.2.6 Rotary Snow Blower

The rotary snow blower shall be provided and attached to the front end of the rail/highway vehicle. It shall consist of the following major components:

- Frame
- Rotary head (1-stage)
- Discharge chute
- Hydraulic actuators

Design features of these components are described below:

Frame - The welded steel frame of the rotary snow blower shall support the rotary mechanism, discharge chute and hydraulic actuators. It shall be attached to the front end of the vehicle frame by means of a quick-disconnect coupling. The frame width shall be _____ ft, ____ in.

A pair of cab-controlled hydraulic actuators shall be provided to raise or lower the snow blower frame with respect to the vehicle. Located on the left and right sides of the frame, they shall be operated by separate controls to raise either side separately; when used together, the snow blower frame will be raised or lowered evenly (without lateral tilt). The vertical stroke of each actuator shall raise or lower the blower frame by at least ____ inches. In its lowest position, the auger shall be within _____ inches of the pavement or the top of the rail.

Special care shall be taken that neither the frame or the rotary mechanism can come into contact with the third rail. All materials possibly coming in contact with the third rail shall be nonconductive. All materials possibly coming in contact with trip arms or other wayside equipment shall be designed so as not to result in damage to the wayside equipment or the vehicle. The Contractor shall present evidence to show that no part of the snow removal equipment will present mechanical interference with any wayside equipment or structures, even on the sharpest curves of the Purchaser's rail network.

Rotary head - The rotary head or the auger shall break up the snow and feed it to a central discharge chute. The rotary head shall be powered by the second (rear-mounted) diesel engine by means of a hydrostatic drive. The speed of the rotary head shall be controllable from the cab. The speed range shall be compatible with the speed range of the vehicle when it is removing snow. Maximum speed shall be _____ rev/min.

The rotary head shall be equipped with helical grooves or cutters to break up and move the snow. The rotary head shall be designed to handle snow of any consistency, including very wet snow and hard, refrozen snow. Width of the rotary head shall be _____ ft, _____ in. Diameter of the rotary head shall be _____ in.

Shear pin protection shall be provided for the auger to protect the rotary head and drive train from damage should foreign objects be ingested and become jammed between the rotary head and the frame. Shear pins shall be located so that they are easily and quickly replaceable using simple tools.

Discharge Chute - A steel discharge chute shall be provided and mounted on top of the frame of the snow blower. This discharge chute shall be hydraulically actuated, with controls inside the cab, to achieve both range and azimuth control of the stream of discharged snow. Three independent hydraulic controls shall be used for the discharge chute:

- Azimuth control - Provision shall be made to rotate the entire discharge chute about the vertical axis. A rotation angle of _____ degrees to each side of the forward direction shall be provided.

- Chute height selection - Provision shall be made to operate with the discharge chute height set to either Low or High. When set on Low, the discharge elevation angle (and throw range) shall be at maximum values. When set on High, a reduced discharge elevation angle shall provide a reduced throw range for the discharged snow.

- Chute discharge flap - Provision shall be made to further reduce the throw range of the discharged snow by means of a continuously variable angle on an exit flap on the discharge chute. Provision shall be made to rotate this exit flap downward, to reduce elevation angle of discharged snow. An angular excursion of this exit flap of _____ degrees shall be provided.

The discharge chute shall be of adequate cross section to minimize the tendency for snow to pack up and block the chute. If blocked with snow, provision shall be made to clear out the chute rapidly using simple tools.

When the discharge chute is in the High position, it shall remain within the dynamic profile provided by the Purchaser.

Hydraulic Actuators - shall be provided to control the following snow blower functions:

- Rotary head (Up or Down on either left or right side, or both sides).
- Discharge chute azimuth (chute rotation about vertical axis).
- Discharge chute height (Low or High positions).
- Discharge chute exit flap (flap angle control).

Controls for all hydraulic actuators shall be conveniently located in the cab for operator use.

A manual emergency backup hydraulic hand pump shall be provided in the cab and be capable of operating the rotary head, and all three discharge chute actuators - all at reduced rates.

9.2.7 Cab and Body

The vehicle shall be furnished with a fully enclosed weather-tight operator's cab that contains all of the controls, switches and instruments necessary for the complete operation of the vehicle and all optional equipment or attachments. The cab shall have sufficient seating capacity for one other crew member, in addition to the operator. The cab and body structure and skin, including fenders and hood, shall be of steel. The cab shall have entry doors on each side, designed for easy and convenient access into the cab. The cab doors shall have automotive-type latch and lock arrangements.

The cab shall be positioned on the vehicle structure high enough for the seated operator to have good forward visibility, even when the rotary snow blower is attached to the front end of the vehicle. The style of the cab shall be the manufacturer's conventional style, so long as it conforms to the requirements in this section.

Cab windows shall consist of:

- A one-piece windshield
- Two side windows with ventilating wings.
- A rear window.

Each side window shall be installed in a cab door. A hand-operated crank shall be provided inside each door for complete roll down of the side window. Each side window shall have a ventilating wing that shall

rotate about a vertical axis and be provided with a locking latch, when closed. The rear window shall consist of either one or two fixed panes.

All cab windows except the windshield shall be laminated safety sheet glass 3/16 in. thick. The windshield shall be laminated safety plate glass 1/4 in. thick. Materials and workmanship shall be in accordance with Section 4.3.3.

The cab shall be equipped with an automotive-type integral heater and fresh air ventilation system, with convenient console controls. This unit shall provide adequate heat to maintain a cab temperature of 55°F under the most severe winter weather (Section 3.1), and shall provide defrosters to blow heated air over both sides to the windshield and the rear window inside surfaces, in sufficient amounts to prevent formation of water or ice on these surfaces.* Temperature and fan speed controls shall be provided for satisfactory and convenient operation of the heater and defroster units.

The windshield shall be equipped with synchronized dual windshield wipers for adequate coverage. Ice shields or rubber-coated wiper blades shall be provided to prevent ice build-up on the blades. Both wipers shall be pneumatically driven with one variable-speed control, conveniently located in the cab. Windshield washers shall be installed near each windshield wiper unit for improved visibility. These washer units shall both be fed from one fluid reservoir which is easily refilled and conveniently located (and supported) under the hood, and controlled by a button on the control console.

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*Electric defoggers may be added to the inside of the windshield and rear cab window, at the discretion of Purchaser.

The cab shall be equipped with a ceiling-mounted dome light, instrument panel back lighting, and a portable map light on a six foot coiled extension cord, all controlled at the console. The cab dome light shall turn on when either cab door is opened.

The driver's seat shall be adjustable to comfortably seat the driver in accordance with the guidelines provided in MIL-STD-1472-C.

The cab shall be provided with automotive-type sun visors on both left and right sides.

The cab shall be equipped with a rear view mirror (automotive type) with a day/night dimmer. External side view mirrors shall also be provided on both left and right sides.

The battery shall be a heavy duty 12 Volt lead acid type with a _____ ampere-hour rating. The battery shall be easily accessible for maintenance and located under the hood.

The cab shall be equipped with a heavy-duty battery cut-off switch. Electrical protection shall also be provided for each electrical circuit with a panel of front-removable, heavy-duty, vibration proof resettable circuit breakers of proper capacity and approved design. Breaker circuits and ratings shall be clearly labeled and breakers shall show whether they are "opened" or "closed".

The vehicle shall be equipped with a pneumatically-operated dual horn mounted outside the cab and actuated by an operator's horn pedal or button in the cab.

A pair of automotive-type headlights shall be provided on the front end of the body. They shall be the sealed beam halogen type, with

high beam/low beam selection and on/off controls located in the cab. Provisions shall be made to aim the beams from the outside. They shall be located on the vehicle so as to conform to all Federal and State highway motor vehicle requirements.

The body exterior shall be equipped with marker and tail lights. The number used, their size, color (red or amber) and their exact placement shall be specified by the Purchaser and shall meet all highway motor vehicle requirements. Marker lights and tail light fixtures shall be of impact-resistant plastic and shall be easily accessible from the outside for lamp replacement.

Automotive type parking lights shall be provided on the front end of the body. They shall be located to conform to highway motor vehicle requirements.

Directional turn signal lights (automotive type) shall be provided.

Braking lights shall be provided and interlocked with the brakes.

Lights shall be provided to illuminate the vehicle registration plate(s) in accordance with State regulations.

The above lights shall be operated from the 12 Volt dc supply.

The headlights, parking lights, registration plate light, instrument panel lights, marker and tail lights shall be controlled by a two-position automotive type light switch on the cab console. The first position shall energize the parking lights, registration plate light, instrument panel lights, marker and tail lights. The second position shall energize the headlights, parking lights, registration plate light, instrument panel lights, marker and tail lights. Means shall be provided on this switch to dim the instrument panel lights.

The cab exterior shall be equipped with a pair of sealed beam floodlights suitable for outdoor use. Each floodlight shall be mounted on the outside of the cab wall just below the roof - one in the right corner and the other in the left front corner. Each floodlight shall be manually aimed from inside the cab, using a remote linkage handle with an integral on/off switch.

The cab exterior shall be equipped with a rotating, amber beacon light mounted on the cab roof and operated by a switch on the control panel. The sealed beam floodlights and the rotary beacon light shall operate from the 12 Volt dc supply.

9.2.8 Fuel Systems

The vehicle shall be equipped with two welded steel fuel tanks, each to supply one of the two diesel engines. Capacity of each tank shall be adequate to supply its diesel engine for 8 hours of continuous operation.

Each fuel tank shall be located to preclude contact with the third rail, and shall be protected to prevent damage from a low-speed vehicle impact.

Each fuel tank shall be provided with a suitable closed fueling system filler neck, with a diameter of at least two inches.

A screen shall be provided in each filler neck, and hinged filler caps that can be locked shall be used. These tanks shall be vented in accordance with best current practices, and in compliance with current Federal regulations.

Each fuel tank shall be provided with an easily accessible drain plug.

9.2.9 Mechanical Propulsion Drive

A mechanical propulsion drive shall be provided to power the primary suspension, using the output of the first diesel engine. This drive shall be fully controlled by the operator in the cab, and shall be engaged with a conventional clutch and a wide-range gearbox.

The drive also shall feature:

- Selectable 2-wheel drive or 4-wheel drive.
- Selectable differential locks (for both front and rear axles).

The entire drive train shall be sized and rated to handle the maximum values of horsepower and torque developed by the first diesel engine, even for extended periods of operation. The lowest gear ratio shall provide a vehicle speed of less than 0.1 mi/hr to provide high tractive effort without clutch slip for heavy plowing operations.

Gear shift levers shall operate in conjunction with the clutch to provide a wide range of gear ratios with a minimum of 12 forward speeds.

A minimum of four reverse speeds shall also be provided.

Shift diagrams for all shift levers shall be provided to assist the operator. They shall be permanently displayed on the lever knobs and on the dashboard, and easily read by the seated operator.

An interlock shall prevent operation of the mechanical drive in either Forward or Reverse unless the center lifting device (Section 9.2.11) is in the fully raised (retracted) position.

9.2.10 Hydrostatic Snow Blower Drive

A hydrostatic drive shall be provided to power the auger of the front-mounted rotary snow blower, using the output of the second diesel engine. This drive shall be fully controlled by the operator in the cab, and shall feature a hydrostatic pump, a hydrostatic motor and suitable fluid lines, reservoir, valves, etc.

The hydrostatic drive shall be sized and rated to handle the maximum values of horsepower and torque developed by the second diesel engine, even for extended periods of operation.

The hydrostatic reservoir shall be designed and tested in accordance with the ASME Boiler and Pressure Vessel Code.

While the second diesel engine shall be operated at nearly constant speed, the hydrostatic drive shall be used to vary the speed of the snow blower auger, as required, by altering the flow rate of the hydrostatic fluid. The maximum fluid flow rate shall correspond to the maximum desired snow auger speed (Section 9.2.6).

Hydrostatic pump and motor seals, and all lines and fittings shall be selected to withstand the highest hydrostatic pressures, with suitable margins for safety.

9.2.11 Center Lifting Device

The vehicle shall be equipped with a center lifting device attached to the underframe for the purpose of reversing the direction of forward travel when the vehicle is rail-mounted. A hydraulically actuated

cylinder shall be activated by the operator to extend the base of the device downward, so that the base of the device rests, by means of support brackets, on the running rails, and raises the entire vehicle in a balanced state.

The vertical stroke of the center lifting device shall raise the vehicle above the rails sufficiently to provide a minimum clearance of 3 inches above the third rail when the vehicle swings out for a half-turn rotation.

The center lifting device shall be provided with a low friction bearing for easily rotating the raised vehicle about the vertical axis. Vehicle rotation shall be possible only after the center lifting device has elevated the vehicle to the fully raised position.

The center lifting device shall provide sufficient lateral support to operate in a proper manner despite any mass unbalance about the lifting center caused by the design of the vehicle, crew movement, or changes in vehicle configuration as fuel or equipment is added or removed.

The center lifting device shall be provided with limit switches to sense when it is in the fully lowered or the fully raised (retracted) positions. A backup latching system shall lock the center lifting device when it is turned Off in either the full-up or full-down position. A cab console annunciator shall indicate when the device is in the fully retracted position; a second annunciator shall indicate when this device is in the fully lowered position. The fully raised (retracted) annunciator signal shall also be used as a propulsion interlock (Section 9.2.9) to prevent vehicle motion unless the center lifting device is fully retracted.

The center lifting device shall be operated with a hydraulic control valve conveniently located inside the cab. This valve shall have three positions:

- Raise
- Lower
- Off

Interlocks shall be provided so that the center lifting device cannot be operated unless:

- The rotary snow blower is Off, and
- The propulsion drive is in Neutral, and
- The parking brake is applied.

The center lifting device shall be operable, at a reduced rate, with the same hand pump used as a back-up for the other hydraulic devices on the vehicle, such as the hydraulic actuators used to rotate and raise or lower the rotary discharge chute.

9.2.12 Cab Equipment and Controls

The cab shall be equipped with all the necessary instruments, gauges, annunciators and controls so that a single operator can drive the vehicle and operate the rotary snow blower and all other equipment (including any optional equipment) used on the vehicle. The layout of the cab equipment, controls and instruments shall follow the guidelines and human factors considerations set forth in MIL-STD-1472-C.

The following dials and gauges shall be used in the cab:

- Speedometer	mi/hr
- Odometer (with trip meter)	mi
- Air pressure (brakes and high-rail wheels)	lb/in^2
- Diesel fuel level*	gal
- Diesel engine tachometer**	rev/min
- Diesel engine oil pressure**	lb/in^2
- Diesel engine coolant temperature**	° F
- Diesel engine hour meter**	hr, min
- Battery ammeter	Amps
- Hydraulic fluid temperature	° F
- Hydraulic pump discharge pressure	lb/in^2
- Hydraulic pump inlet pressure	lb/in^2

The following devices shall be provided in the cab for the operator's control of the vehicle and optional equipment (if used):

- Diesel engine throttle (speed control)*	(cont. low-to-high)
- Diesel engine shutdown button*	(on/off)
- Diesel engine emergency shutdown button*	(on/off)
- Diesel engine keyed ignition/start switch*	(on/off/start)
- Diesel engine cold start button (if used)*	(on/off)
- Brake pedal	(apply/release)
- Parking brake	(apply/release)
- Emergency hand pump (hydraulic)	(manual)
- Snow blower throttle (speed control)	(cont. low/med/high)
- Snow blower head elevation (for left side)	(up/down)
- Snow blower head elevation (for right side)	(up/down)
- Discharge chute azimuth angle	(cont. left to right)
- Clutch	(engage/disengage)
- Gear shift lever	(manual)

*One for each diesel fuel tank.

**One for each diesel engine.

- Discharge chute height (low/high)
- Discharge chute exit flap angle (angle position)
- Horn foot pedal (or button) (on/off)
- Windshield wiper knobs (front and rear) (variable speed)
- Windshield washer buttons (front and rear) (on/off)
- Cab heater/defroster controls
  - defroster (front and rear) (on/off)
  - heater (on/off)
  - heater temperature (off/cold-to-hot)
  - heater fan (4 speeds) (off/1, 2, 3, 4)
  - defroster fans (4 speeds) (front and rear) (off/1, 2, 3, 4)
- Sanding button (on/off
- Center lifting device (up/down/off)
- Hydraulic pump controls (if used) (off/low-to-high)
- Power take-off controls (if used) (off/low-to-high)

The following lighting controls shall be provided in the cab and conveniently located for the operation.

- Headlights, etc. (on/off)
- Headlight high beams (high/low)
- Floodlights (individually controlled) (on/off)
- Beacon light (on/off)
- Cab dome light (off/on/dimmer)
- Map light (on/off)

The following indicator lights shall be provided on the instrument console for the operator's information:

- Diesel oil pressure Low*
- Diesel coolant temperature High*
- Beacon light On
- Headlight high beam On
- Snow blower in operation
- Diesel fuel Low (propulsion)
- Diesel fuel Low (snow blower)
- Center lifting device fully retracted
- Center lifting device fully lowered
- Center lifting device angle alignment (to rails)

9.2.13 Sanders

Two sanders shall be provided to improve rail traction. They shall deposit sand on the rails in front of each of the two rubber-tired rear wheels.

Each sander shall consist of a sandbox, a nozzle, and a flow actuator. The sandbox shall be located to permit easy filling from outside the vehicle, with fill openings at least 3 inches in diameter. Fill covers shall be hinged and gasket seals used to keep out water. Capacity of each sandbox shall be at least one cubic foot.

Sander nozzles shall be located as close as possible to the rails and rubber tires, and shall be designed to reject water caused by wheel splash.

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*One for each diesel engine.

Sanders shall be operated from the cab either by air pressure or by electrical means. A single flow rate shall be provided, which shall be easily adjustable by maintenance personnel. Sander controls shall operate both sanders at once, using a single control button.

9.2.14 Optional Equipment

The following types of optional equipment shall be available to augment the snow fighting capabilities of the rail/highway vehicle:

- Front-end plows - to clear right-of-way.
- Front-end brooms - to clear right-of-way.
- Front-wheel sanders.

If any of the above types of optional equipment are selected by the Purchaser for the vehicle, then the paragraphs below that pertain to the selected optional equipment shall apply.

Front-End Plows - Two types of front-end plows are available:

- V-shaped plow.
- Straight-bladed plow.

The following features shall apply to either type of front-end plow:

- The front-end plow shall be made of steel and its design shall be suitable for its intended use. Materials and workmanship shall conform to applicable portions of Section 4.
- A quick-disconnect type of mount shall be used to attach the plow to the front end of the vehicle.

- The operation of the plow shall be fully controlled from inside the cab, and hydraulic actuators shall be used to:
  - Raise and lower plow.
  - Rotate plow to either left or right (straight-bladed type only).

  The plow shall be raised and lowered with a total vertical stroke of ____ inches. At its lowest position, its bottom edge shall be ____ inches above the top of the rail. This rail clearance shall be easily adjustable by maintenance personnel. The straight-bladed plow (if used) shall be capable of being rotated _____ degrees to either side, under cab control.

- Overall width of the front-end plow shall be _____ ft.

The following features shall apply to a rotary broom mounted on the vehicle front end:

- The rotary broom shall have a cylindrical shape with its spin axis horizontal and nominally normal to the forward-pointing axis. It shall be made of steel and have non-conducting*, long-wearing bristles of suitable length and stiffness for the intended purpose. Materials and workmanship shall conform to applicable portions of Section 4.
- A quick-disconnect type of mount shall be used to attach the rotary broom to the front-end of the vehicle.

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*Broom bristles shall provide insulation sufficient to withstand 3000 V dc per inch of bristle length, in accordance with IEEE Std. 11-1980.

- The rotary broom shall be fully controlled from inside the cab, and hydraulically powered. These controls shall:
  - Raise and lower the broom.
  - Rotate the broom to either left or right.
  - Adjust the rotating speed of the broom.

The broom shall be raised and lowered with a total vertical stroke of _____ inches. At its lowest position, its bristle tips shall be nominally _____ inches above (or below) the top of the rail. This vertical rail clearance shall be easily adjustable by maintenance personnel, if desired, so that the broom can be lowered further until its bristles touch the tops of the ties, if desired.

The broom shall be capable of being rotated _____ degrees to either side, under cab control.

The rotational speed of the broom shall be continuously adjustable with a throttle control located inside the cab. The maximum broom rotational speed shall be based on the maximum vehicle forward speed (when sweeping snow) and the diameter of the cylindrical broom.

Overall width of the rotary broom shall be ____ ft, ____ in.

The overall diameter of the rotary broom shall be ____ ft, ____ in.

Both front-end plows and front-end brooms shall be useable for either highway or rail operations.

Additional options may be available that could outfit this vehicle for a variety of other tasks, and for rail and highway operations in other seasons of the year. For this reason, hydraulic fittings and power take-offs shall be provided at each end of the vehicle so that hydraulic pumps, hydraulic actuators, and belt-driven auxiliary devices and optional equipment can be easily installed and used, as needed. Typical additional optional equipments and devices are:

- Fork lift attachment.
- Back hoe attachment.
- Bulldozer attachment.
- Grader attachment.
- Roadside grass cutter.

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etc.

Front-Wheel Sanders - An additional pair of sanders, similar to the sanders used for the rear rubber-tired wheels (Section 9.2.13) may be provided for the front rubber-tired wheels for improved traction on ice and snow. These front-wheel sanders shall be similar to the rear-wheel sanders in all aspects of design, installation and operation; they shall operate whenever the rear sanders operate, as described in Section 9.2.13.

Appendix A

Test Procedure to Verify

Snow Removal Rate

The rate at which snow can be cleared from the right-of-way is the fundamental performance parameter of any rail-mounted snow removal vehicle. This appendix describes the test procedures used to determine this parameter. These procedures are applicable to all three types of snow removal vehicles.

In order to perform this snow-fighting acceptance test, a snow-covered section of test track must be made available. Depth of snow cover should be at least one foot above the top of the rails, and the length of the test track should be a minimum of 50 feet (100 feet is preferable). The width of snow cover should exceed the expected width of cut by at least two feet. Natural snow is preferable to artificial snow, which in turn is preferable to trucked-in snow. However, all three types of snow are considered acceptable for this test of the snow removal rate.

The snow removal rate shall be determined by performing the four test procedures listed below, in the sequence shown:

1 - Determination of average depth of snow.
2 - Determination of average density of snow.
3 - Determination of average vehicle velocity (while removing snow).
4 - Determination of average width of cut.

The first two procedures must be carried out within 30 minutes before the third procedures (the actual snow removal) is performed. Details of these three procedures follow.

Snow Depth (H) - The average snow depth (above the top of the rails) in the test section shall be determined as the arithmetic mean value of at least ten measurements, more or less equally spaced along the test section, with roughly half of the measurements over each running rail.

Each measurement shall be made with a rigid yardstick, which shall be pushed vertically down into the snow directly above a running rail until it makes contact with the rail. Depth of snow shall then be read and recorded in feet (to the nearest tenth of a foot).

Snow Density (W) - The average snow density in the test section shall be determined as the arithmetic mean value of at least six measurements, more or less equally spaced along the test section, with roughly half the measurements taken on each side of the test section.

Each measurement shall be made by pushing a steel cylindrical can of a known internal volume (and both ends removed) down into the snow until completely filled and immersed. The can shall then be carefully "cut" out of the snow with a flat blade to avoid packing the snow in the can, which would increase the apparent snow density. The snow inside the can shall then be carefully transferred to a plastic container and weighed on an approved scale, making allowance for the weight of the empty plastic container. Volume of the metal can shall be at least one quart. The density shall be expressed in units of pounds mass per cubic foot and calculated to the nearest tenth of a lb/ft^3.

Vehicle Velocity (V) - The average vehicle velocity achieved during this snow removal test shall be determined by measuring the time required to clear out the measured test section. An approved stopwatch that measures to tenths of a second shall be used, and the average velocity shall be expressed in feet/second and calculated to the nearest tenth of a ft/s

Cleared Width (B) - The average width of the cleared swath shall be determined by direct measurement after the test. At least six measurements shall be taken with an approved tape measure (held by two persons)

and measurements shall be taken down near the top of the rails as well as higher up along the cut. Cleared width shall be expressed in feet and determined to the nearest tenth of a foot.

The snow-removal rate (R), expressed in tons per hour, shall then be calculated from the four test parameters using:

$$R = \left(\frac{3600}{2000}\right) \times W \times B \times H \times V$$

Comparison of this calculated value with the specified value shall determine the adequacy of the vehicle's snow removal capability.

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